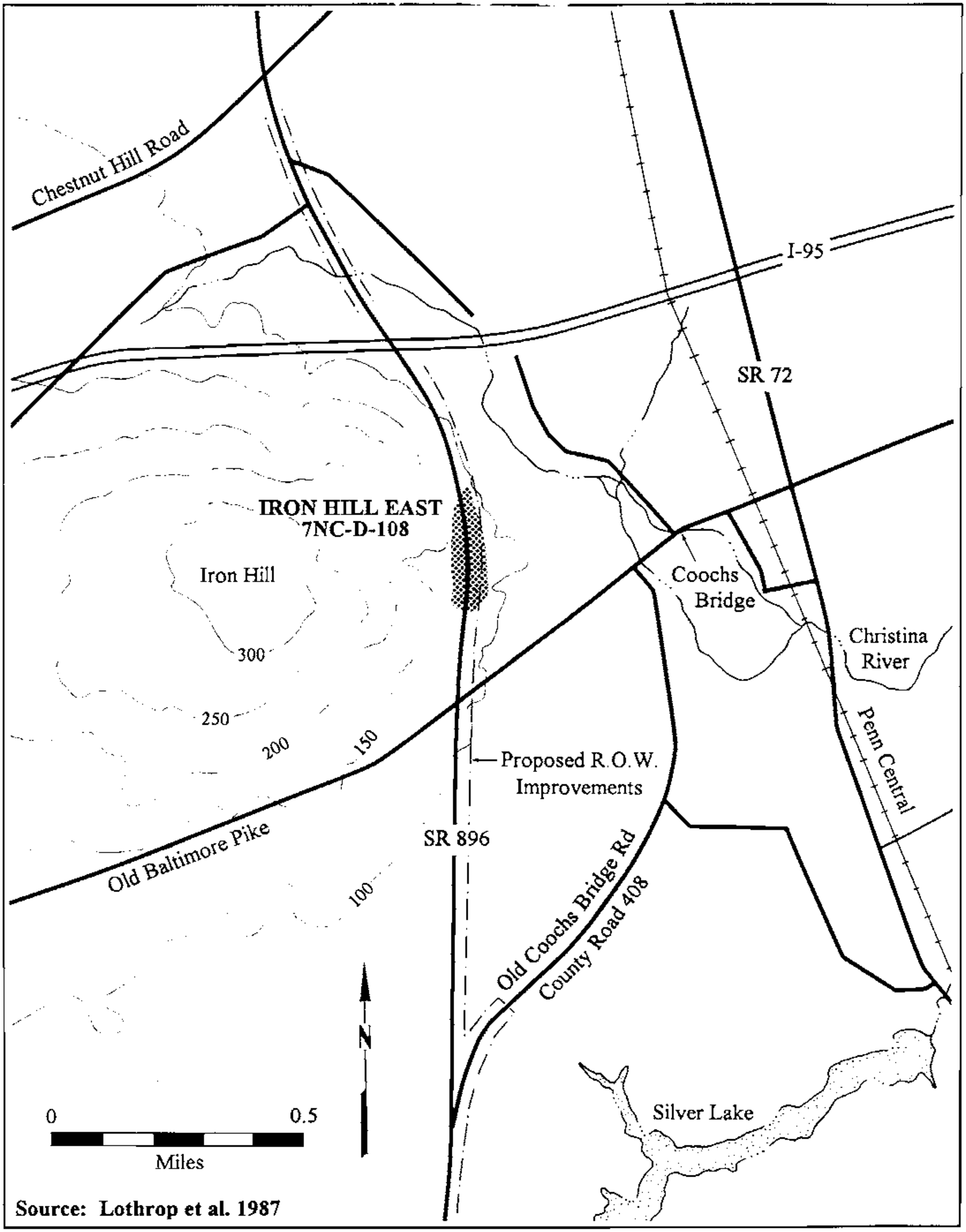
VIII. IRON HILL EAST (7NC-D-108)

A. Location and Current Conditions

The Iron Hill East Site is located on the east slope of Iron Hill, the southernmost outlier of the Piedmont geologic Province in Delaware (Figure 8-1). Iron Hill is primarily composed of igneous and metamorphic rocks, surrounded by Coastal Plain sediments (Melson 1969).

The Iron Hill East site is located south of Interstate 95 and on both sides of SR 896. Highway construction and commercial and residential development in the vicinity of Iron Hill has probably had a major impact on cultural resources (Lothrop et al. 1987). Current archaeological investigations were confined to the eastern margin of the SR 896 right-of-way (Figure 8-2, Plates 8-1, 8-2). This portion of the site is currently under corn agriculture, although in its northern third, the site is within secondary growth woods, with an inactive plow zone. The terrain generally slopes towards the east. The site is bisected by a small unnamed ephemeral drainage and smaller streams running east towards the Christiana River. Elevations range from about 120 to 130 feet above mean sea level throughout the project area.

There are three predominant soil associations in the site area, Neshaminy and Montalto silt loams or silty clay loams over most of the project area, Watchung and Calvert silt loams in the woodline in the northern third of the site, and Aldino silt loam on the north side of the ephemeral stream (Matthews and Lavoie 1970). These soils are poorly drained to well-drained and developed as a resulted of in situ weathering. Subsoil is often close to the surface, gravelly areas are usually found, and gullying is fairly common. Often these soil associations have lost part of their original surface layer through erosion, and in some cases the loss may be severe.



SR 896

Figure 8-1
Iron Hill East
Location

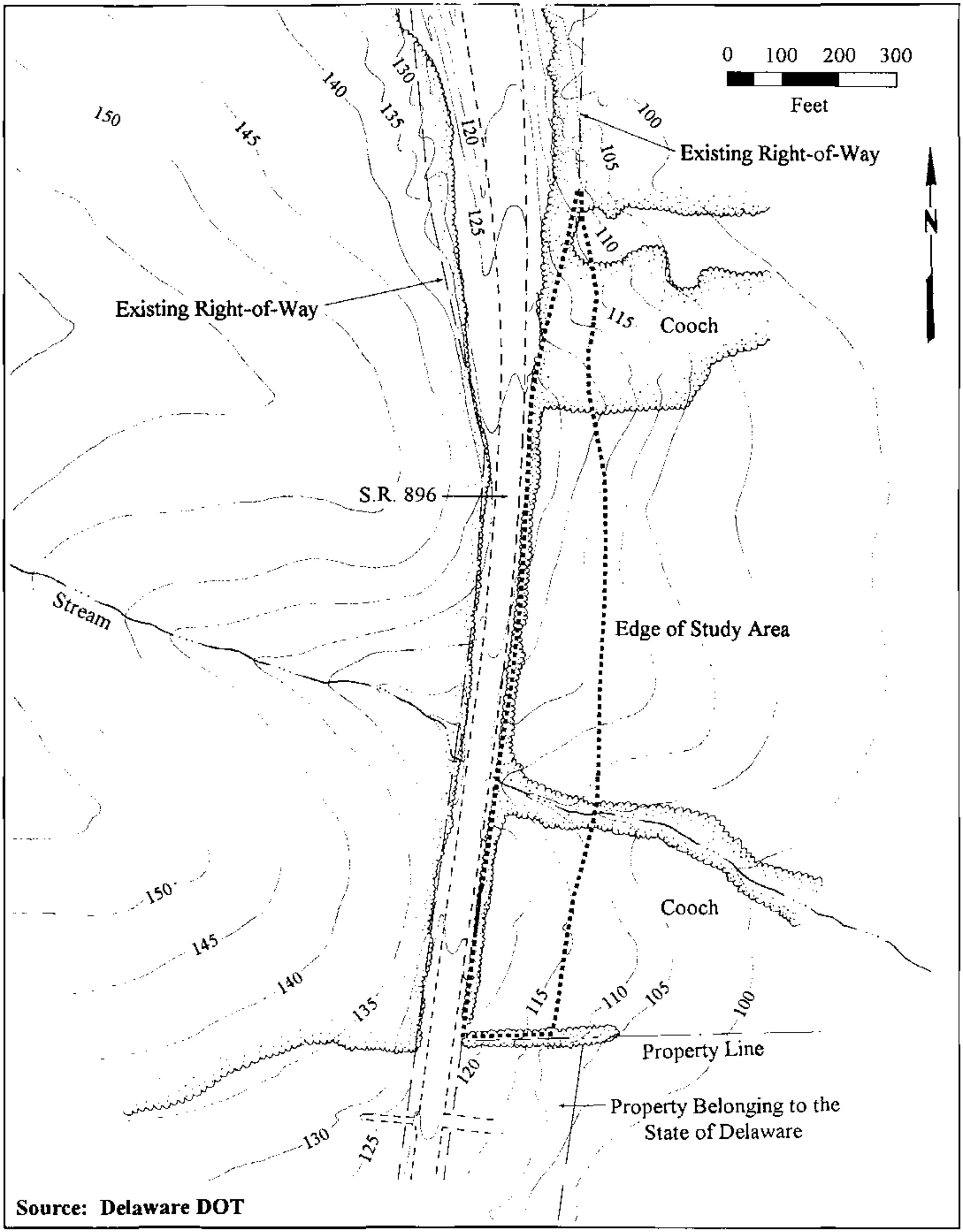


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Figure 8-2
Iron Hill East
Current Study Area Boundaries

Plate 8-1

Iron Hill East: Aerial View Looking North Along Existing SR 896 Right-of-Way

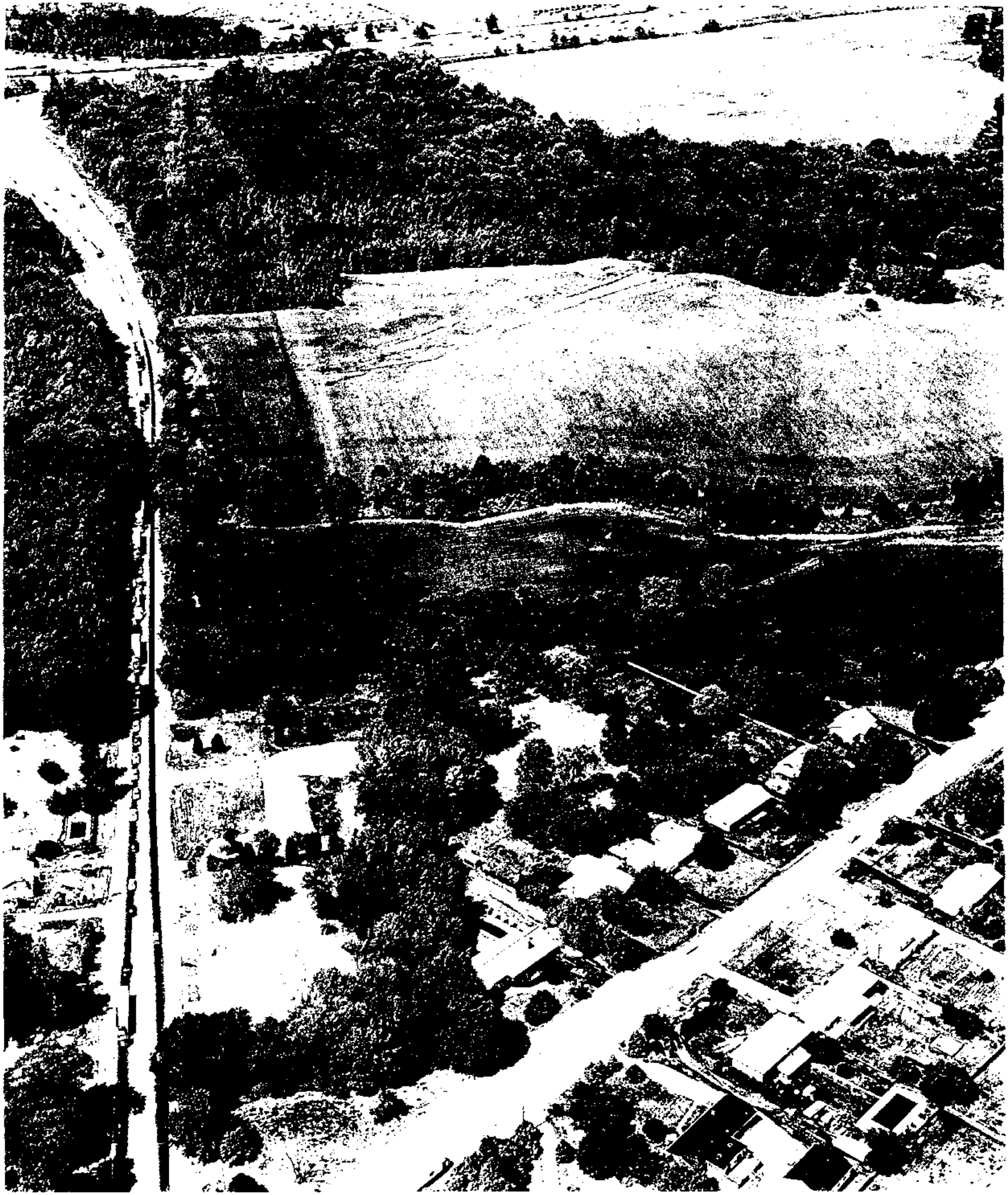


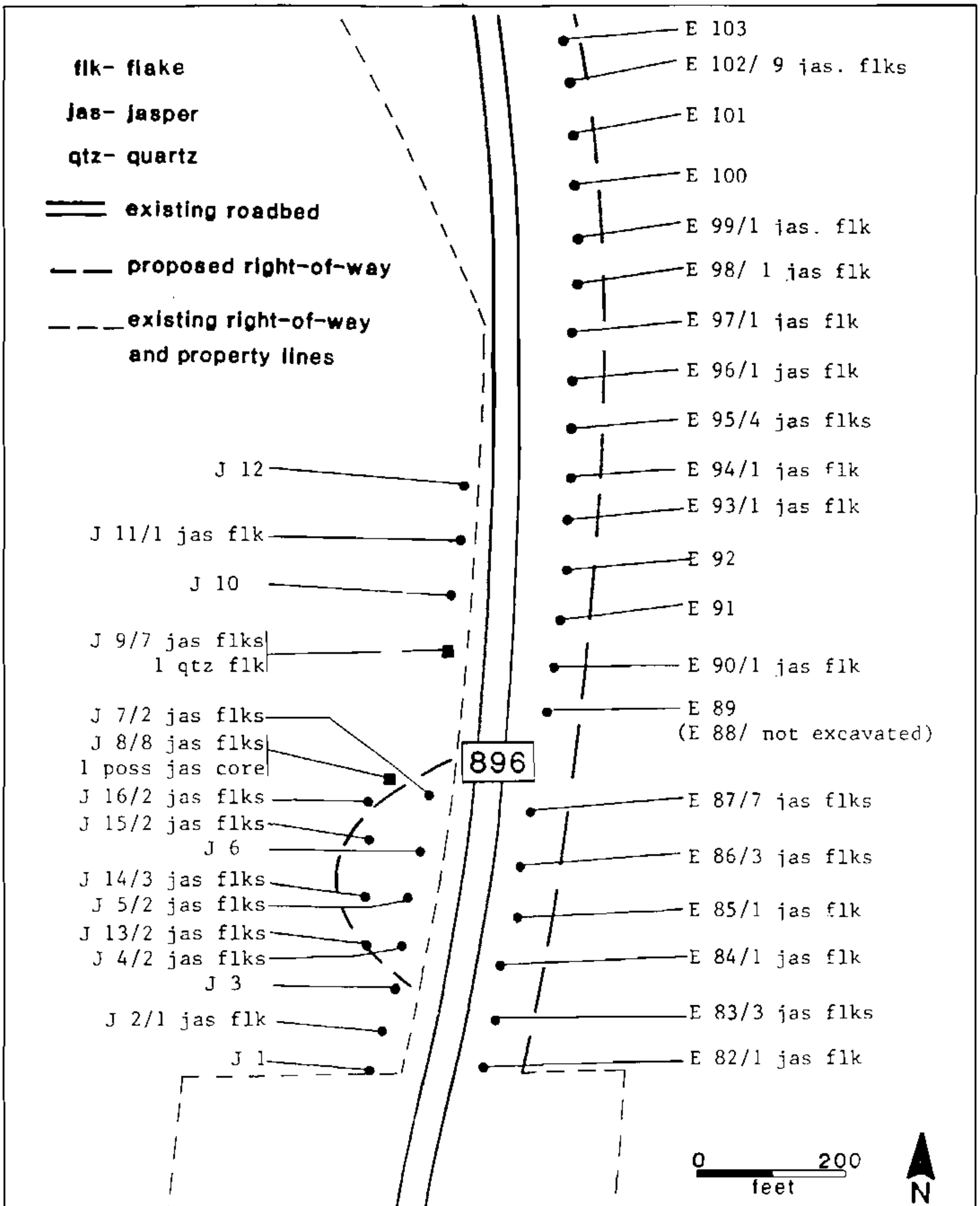
Plate 8-2

Iron Hill East: Aerial View Looking Northeast, Showing Detail of Southern Portion of Shovel Test Grid

B. Field Strategy

During survey of the proposed widening of the SR 896 corridor, the University of Delaware identified the Iron Hill East site (Lothrop et al. 1987). The field investigations indicated that prehistoric materials were present on both the eastern and western margins of the highway corridor, situated on the eastern slope of Iron Hill (Figure 8-1). During Phase I survey shovel test pits were excavated at 20 m intervals (Figure 8-3). Two $1m^2$ test units were excavated on the west side of SR 896, on the north and south sides of the unnamed stream. The southern edge of the project area was marked by disturbance by existing houses. Of the 35 shovel test pits excavated in Phase I, 25 produced a total of 56 artifacts, all classified as jasper flakes or flake fragments. The two test units produced 22 jasper flakes, one quartz flake, and one possible jasper core fragment. At this shovel test interval, clear differences in artifact distributions were not witnessed. Most shovel tests contained 1-3 artifacts, although two shovel tests on the east side of SR 896 contained a higher density of artifacts, Shovel Test E 87 produced 7 flakes, and Shovel Test E 102 produced 9 flakes. Although surface visibility was low, a jasper uniface was recovered near Shovel Test E-90. No temporally diagnostic material was recovered to date the site.

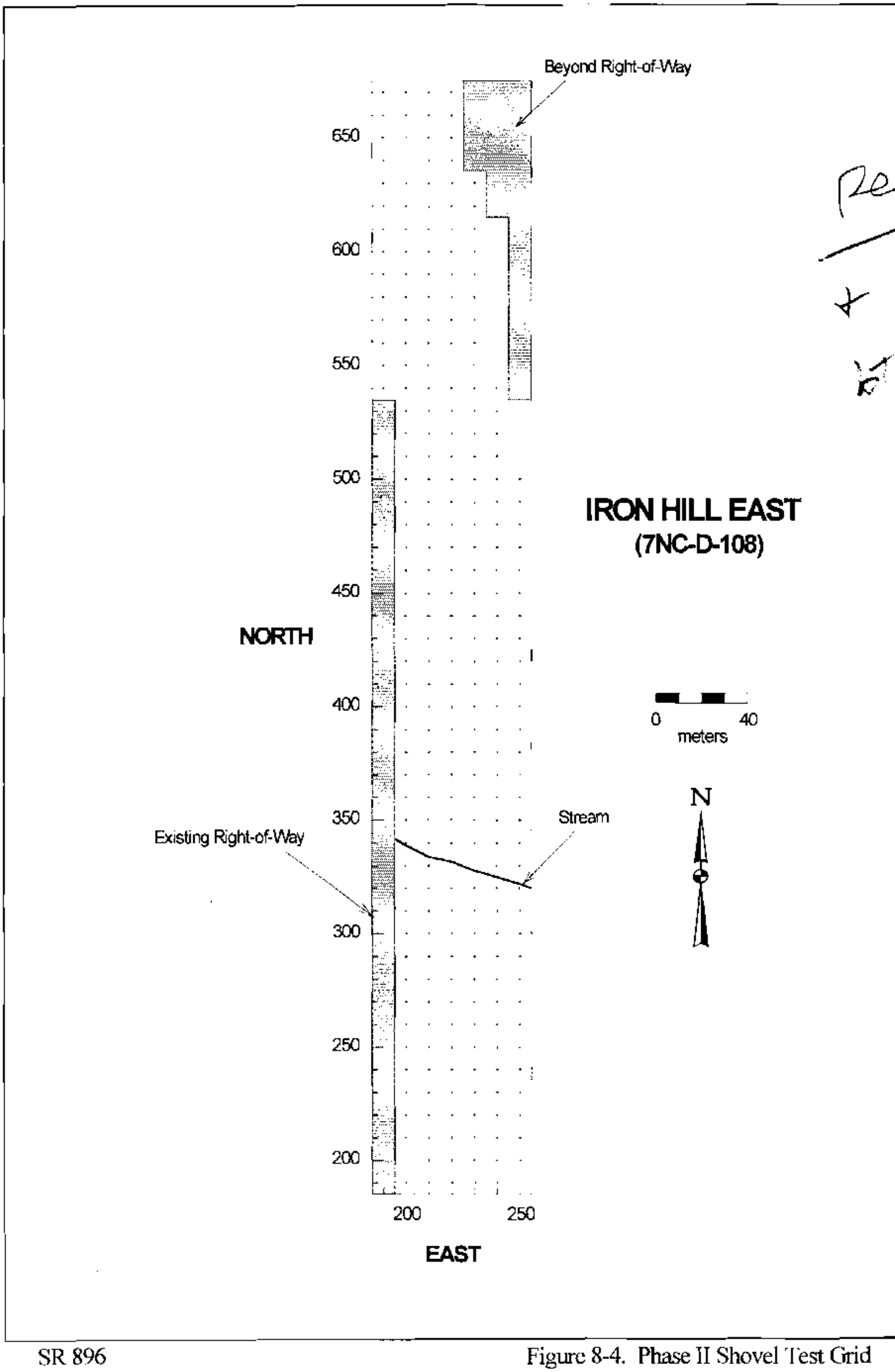
Phase II evaluative testing of Iron Hill East was performed by the Cultural Resources Division of Parsons Engineering Science, Inc. The goal of the Phase II testing was to evaluate the significance of Iron Hill East in terms of National Register criteria. The Phase II testing was geared towards delimiting the horizontal and vertical site boundaries, and assessing stratigraphic integrity and chronological affiliation. Field proveniences were controlled by placing a grid over the area using an electronic theodolite. The Phase II testing program consisted of the excavation of a total of 268 shovel test pits on a 10x10m grid superimposed over the project area (Figure 8-4). Close interval shovel tests, at 5m intervals, were placed around selected test pits in the initial grid to explore potential artifact concentrations. To provide detailed overviews of stratigraphy and examine artifact density and type, six $1m^2$ test units were placed in locations selected on the basis of the combined shovel test data.



Source: Lothrop et al. 1987

SR 896

Figure 8-3
Iron Hill East
Results of Phase I Shovel Testing



Reduce
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Figure

SR 896

Figure 8-4. Phase II Shovel Test Grid

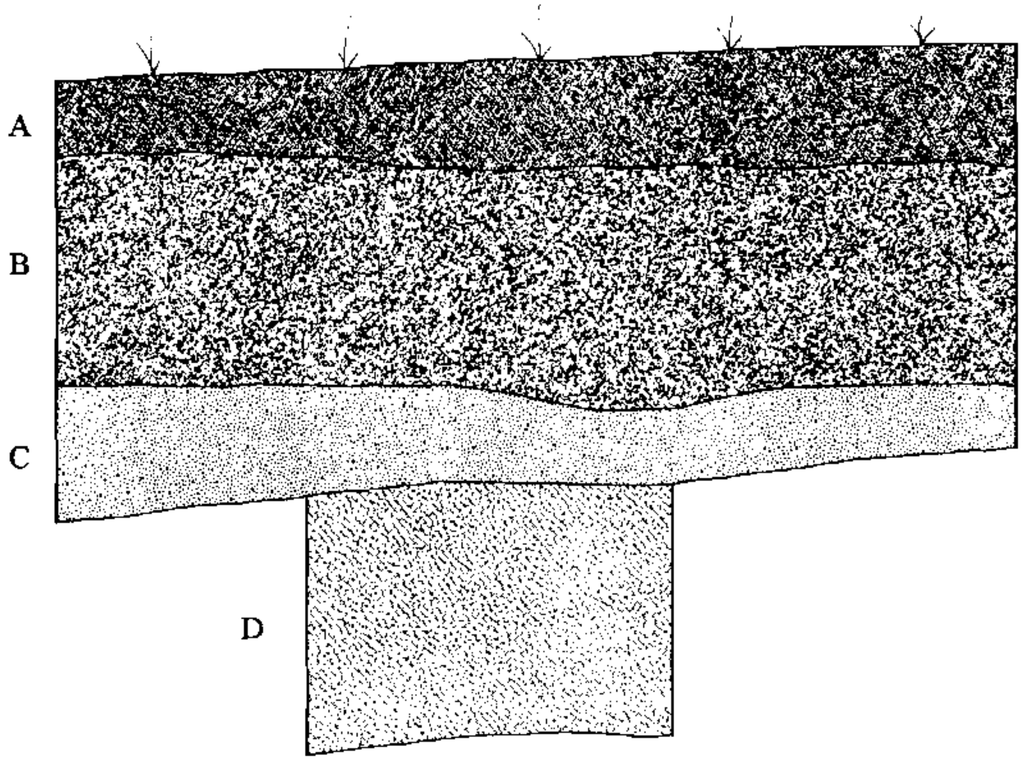
C. Findings

1. Stratigraphy

The stratigraphy at Iron Hill East was relatively straightforward, in that most excavated proveniences consisted of a plow zone (Stratum A), about 10-15 cms in thickness, overlying a silty loam (Stratum B), ca. 10-30 cms in thickness. All historic and prehistoric artifacts from the site were recovered from Stratum A. Unit 4 (N336 E242), located north of the stream, and in an area of high artifact concentration, was excavated to a maximum depth of ca. 74 cms to demonstrate the natural stratigraphy that may be encountered in the site (Figure 8-5). Stratum A, a plow zone, was 12 cms in thickness, consisting of a brown (10YR 4/3) silty loam. Stratum B was 24 cms in thickness and consisted of a yellowish brown (10YR 5/4) silty loam. Stratum C was 12 cms in thickness, consisting of a grayish brown (10YR 5/2) clayey and silty loam. Artifacts from all proveniences were confined to Stratum A, the plow zone. Stratum D was 26 cms in thickness, consisting of a light brownish gray (2.5Y 6/2) silty clay mottled with a yellowish brown (10YR 5/4) silty clay. Stratum D was also densely packed with weathered material and large angular pieces of bedrock.

2. Historic Period Data

No structures appear within the study area on historic maps, nor is it clear whether there were military engagements in close proximity to the area. During the Phase I survey of the SR 896 right-of-way, no historic resources were encountered (Lothrop et al. 1987). The potential for cultural resources relating to the Revolutionary War battle known locally as the Battle of Cooch's Bridge was considered low, since military engagements usually produce low density, discontinuous distributions of material (Lothrop et al. 1987). Thus, only scattered historic period artifacts were expected at the site.



Key:

Stratum A (0-12 cm): 10YR 4/3 brown silty loam, plow zone
Stratum B: (12-36 cm): 10YR 5/4 yellowish brown silty loam
Stratum C (36-48 cm): 10YR 5/2 grayish brown clayey and silty loam
Stratum D (48-74 cm): 2.5Y 6/2 light brownish gray mottled with 10YR 5/4 yellowish brown silty clay densely packed with weathered material and large angular pieces of bedrock

0 20
Centimeters

Source: Parsons Engineering Science

SR 896

Figure 8-5
Iron Hill East
Test Unit 4
South Profile Section

Artifacts

Systematic subsurface testing resulted in the recovery of 69 historic period artifacts distributed in low frequencies across most portions of the site area. The artifacts, summarized in Table 8-1, generally consisted of architectural and other hardware, along with domestic debris in the form of ceramic fragments and vessel glass. The refined earthenwares included five sherds of pearlware (2 shell-edged and 3 undecorated); eight fragments of whiteware (5 undecorated, 2 annular decorated, and 1 transfer printed); three fragments of undecorated ironstone, and two small spalls of unidentifiable refined earthenware (1 fragment of hand-painted glaze, and 1 burned fragment with no recognizable characteristics). Hardware from the site consisted of nails (3 cut, 2 wire, 1 untyped), and several fragments of wire. A lead musket ball, measuring 1.6cm in diameter, was also recovered. Coal and brick occurred across the entire site area. The presence of these two materials was noted on excavation forms, but systematic samples were not retained and frequencies were not quantified. In general, historic period artifacts were distributed thinly and randomly across the field, and appeared typical, both in character and frequency, of the type of historical debris recovered from heavily plowed fields.

Table 8-1. Iron Hill East: Historic Period Artifact Frequencies

Group	Class or Type	Count	Frequency
Architecture	Nails	6	9%
	Window Glass	12	18%
	Roofing Slate	1	1%
	Linoleum Tile	1	1%
Domestic/Industrial	Barbed Wire	10	15%
	Miscellaneous Hardware	2	3%
Domestic	Refined Earthenware	18	26%
	Coarse Earthenware	7	10%
	Stoneware	1	1%
	Bottle or Vessel Glass	10	15%
Arms	Bullet	1	1%
Total		69	100%

Spatial Distribution

The mapped distribution of all historic period artifacts based on the systematic shovel test data from the site area is illustrated in Figure 8-6. Artifacts were thinly dispersed across the area, with only one provenience containing more than three artifacts. The shovel test at N320 E220, adjacent to the intermittent stream, yielded 10 artifacts, all fragments of barbed wire. Similar fencing was observed in place along the stream, suggesting a likely, recent source for the material.

As indicated by the general distribution map, most of the historic period artifacts occurred within 30m of the existing right-of-way of SR 896. Although no individual artifact types were present in high frequencies, distributions of major classes were examined for potential patterning. Construction material, including window glass, brick, and the few nails recovered from the site, were scattered across the site area. Ceramic fragments exhibited some separation by ware type, although the implications of the distribution were unclear due to the low frequencies involved (Figure 8-7). Pearlware, for example, was recovered only in the north-central portion of the study area, between N490-N540 and E200-E220. In contrast, most of the later refined earthenwares from the site—whiteware and ironstone—occurred south of the stream, generally between N200-N240 and E210-E250. Coarse earthenwares (mainly glazed redwares) were recovered in both areas, though a single fragment of trailed-slipware was recovered along with the pearlwares. Regionally, trailed-slipwares, such as those from Pennsylvania, can date to the late-eighteenth to early-nineteenth century, though they were more common into the mid-nineteenth century (Ketchum 1991: 89), and thus the date range was arguably close to that of the pearlware recovered in the same area. In addition, a lead musket ball from a smooth-bore weapon was recovered from this portion of the site (at N510 E220). Smooth bore arms were used by the military until the late 1850s (Coates and Thomas 1990). There is no direct evidence to suggest that the musket ball came from a military weapon, but the artifact could fit chronologically with the ceramics from that part of the site.

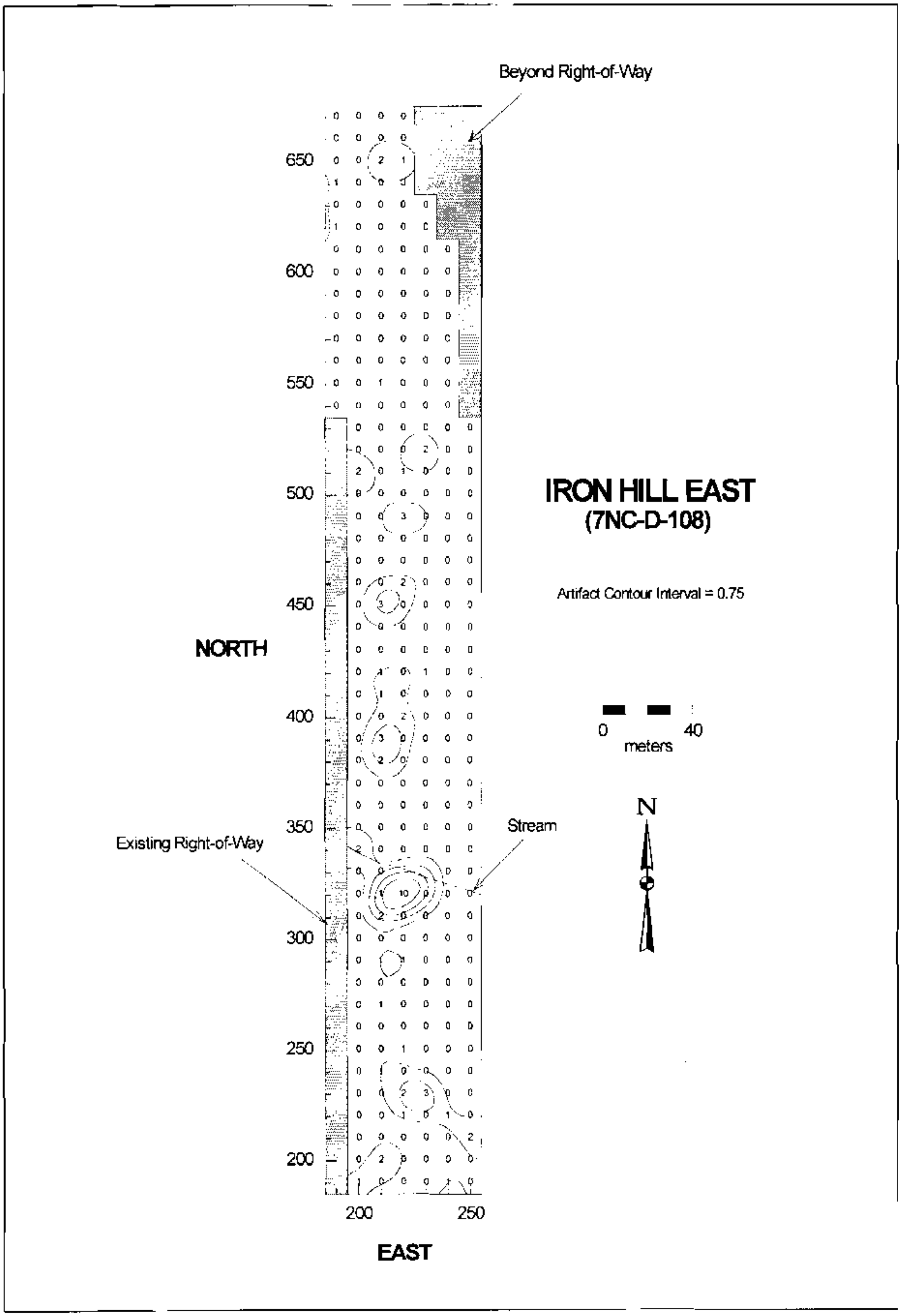


Figure 8-6. Historic Period Artifact Distribution

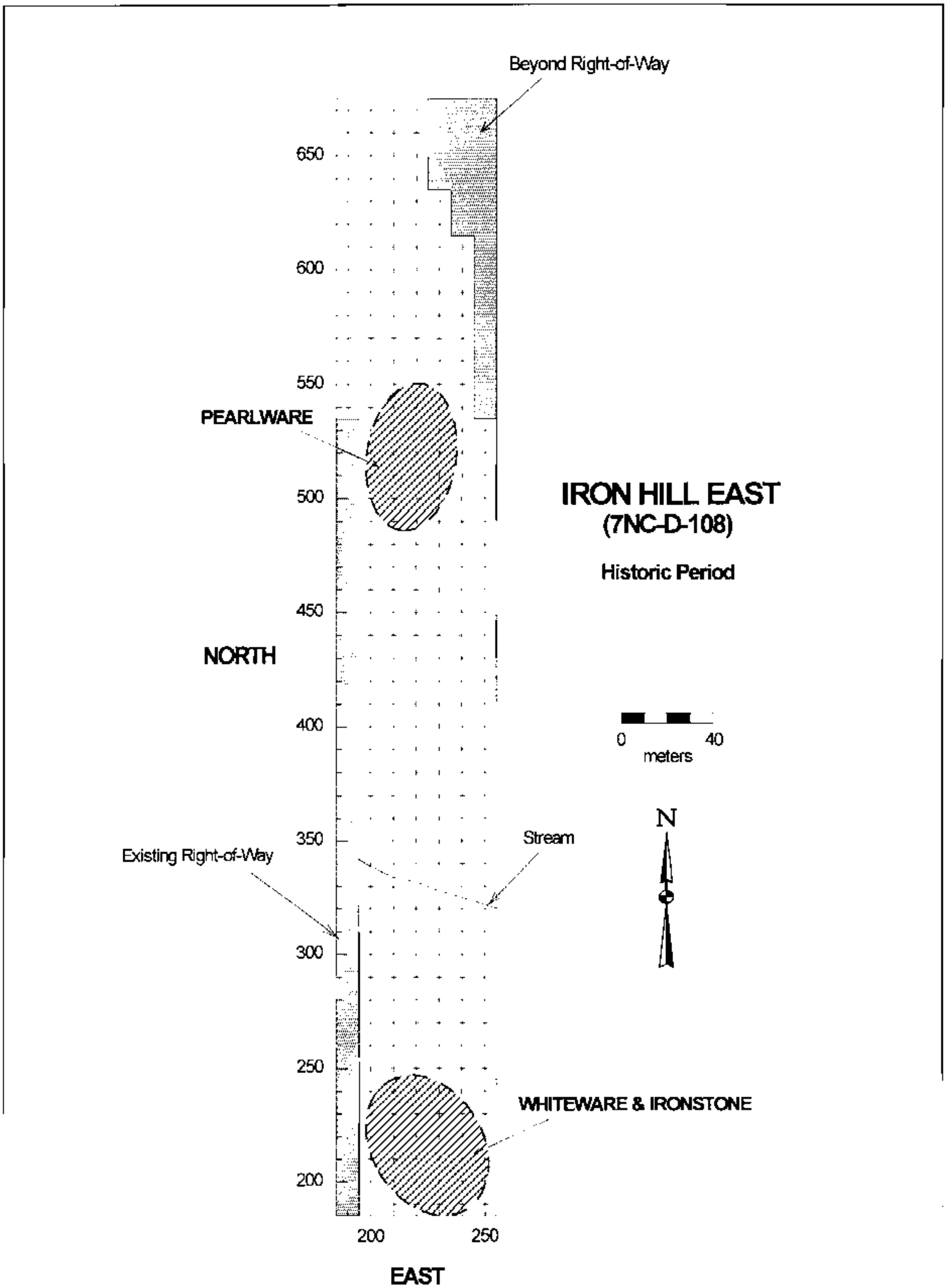


Figure 8-7. Distribution of Selected Historic Period Ceramic Types

In the end, the relatively small amount of data rendered interpretation of the spatial distributions difficult. The lack of high artifact counts or observable clustering among the historic period materials suggests that the material was not related to unmapped structures, but rather was typical of the debris associated with the margins of a heavily traveled road or that are generally found in a heavily plowed field (Delaware State Historic Preservation Office 1993:45).

3. Prehistoric Data

Artifacts

Of the 825 prehistoric artifacts recovered from the site, most consisted of lithic debris. Totals are listed in Table 8-2, while lithic raw material frequencies are detailed in Table 8-3. Although the majority of this debris did not exhibit classic flake attributes, 55 definite flakes or flake fragments were identified. Raw material types among these flakes included jasper, quartz, quartzite, chert, ironstone, and rhyolite, in descending order of frequency. The remainder of the lithic material consisted of 766 fragments of either coarse, granular jasper or limonite, the latter comprising the material in which the higher-quality cryptocrystalline jasper occurs. Due to difficulties in confidently distinguishing among the pieces between artifacts and natural spalls, the material was placed in a general debris category identified in the artifact inventory as chips.

Table 8-2. Prehistoric Artifact Frequencies

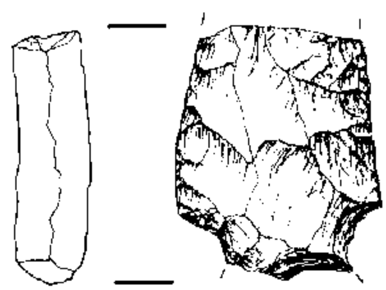
Morphological Type	Count	Frequency
Chips	766	93%
Flakes	55	6%
Cores	1	<1%
Projectile Points	1	<1%
Hammerstone	1	<1%
Fire-Cracked Rock	1	<1%
Total	825	100%

Table 8-3. Iron Hill East: Lithic Raw Material Frequencies for Prehistoric Artifacts

Lithic Material Type	Count	Frequency
Jasper	794	96%
Quartz	18	2%
Quartzite	8	<1%
Chert	3	<1%
Ironstone	1	<1%
Rhyolite	1	<1%
Total	825	100%

Projectile Point

A single projectile point was recovered from the excavations. It consisted of the medial section of a relatively broad-bladed point manufactured of red jasper (Figure 8-8). Breakage consisted of a snap extending transversely across blade. In addition, most of the hafting element was missing, truncated in a perverse break at what appeared to have been the neck. Two characteristics indicated that the point had been notched, as opposed



Red Jasper
#71-3

Figure 8-8. Projectile Point Fragment.

to stemmed: 1) the hafting element exhibited a slight outward flare on one side at the break, and 2) the location of the break, at what would have been the narrowest and thus the weakest part of the hafting element. The angle of the notch suggested that the point was probably side-notched. Blade edges were straight, but showed some signs of resharpening in the form of an asymmetrical outline above the shoulders, possibly indicating reworking while the biface remained hafted. The point measured 27mm at the shoulders, 16mm at the neck, and 10mm at its thickest point, resulting in a relatively high width:thickness ratio of 2.7. Damage to the blade and hafting element were consistent with that induced experimentally through use as a projectile (Flenniken and Raymond 1986; Towner and Warburton 1990). There was no other macroscopic evidence indicating possible forms of use.

The point shared attributes with several side-notched types occurring in Delaware, including later Paleo-Indian (Early Archaic) types such as Palmer or Kirk (as defined by Coe [1964] and Broyles [1971]), and the Late Archaic Brewerton Side-Notched type (as defined by Ritchie [1971]). The specimen was too fragmentary, with an insufficient amount of the hafting element remaining, to allow confident typing. Since this was the only potentially chronological data recovered from the study area, temporal affiliation could not be advanced for the site at this stage.

Core

One small, amorphous core fragment was recovered. The raw material consisted of dense red quartzite (178gm). Flaking was multi-directional, and no remnant cortex was present.

Hammerstone

A single hammerstone, a small, oval, disk-shaped specimen of quartzite, was recovered. The artifact was dense, weighing 305gm. Moderate battering was observed at both ends, one face was smooth, and one displayed a minor amount of battering suggesting minimal use as a bipolar hammerstone.

Fire-Cracked Rock

One fragment identifiable as fire-cracked rock was recovered. The lithic material consisted of reddened quartzite. The specimen weighed 160gm.

Lithic Debris/Chips

In their report on the Phase I investigation of the Iron Hill East site, Lothrop et al. (1987: 186) stated that the jaspers occurring at Iron Hill vary in quality, with masses of good, flakeable stone usually found as irregular nuclei surrounded by large amounts of much poorer siliceous stone, or limonite. As part of the Phase II analysis, the material recovered during Phase I was reviewed at the University of Delaware's Center for Archaeological Research. It was observed that most of the lithics from the initial survey of the site consisted of poor-quality siliceous stone, although some examples of higher quality cryptocrystalline stone were present.

On the whole, the Phase II findings corroborated the observations made during Phase I. In many cases, it was difficult to determine if the lithic material recovered from the site was artifactual or natural. Some of the debris from shovel tests and test unit excavations was clearly not artifactual, consisting of amorphous, rounded and blocky material, without signs of deliberate flaking. The majority of the material retained from the excavations did bear evidence that could be interpreted as resulting from percussion flaking. Among the attributes that showed intentional flaking were relative proportions (e.g., width:thickness ratios), sharp edges, and the presence of platforms. Material quality varied from low (Plate 8-3) to high (Plate 8-4), sometimes within a single piece (Plate 8-5). In addition, many of the pieces were reddened, suggesting heat treatment. The problem of artifact identification is not unique to Iron Hill East, but is a problem commonly encountered at prehistoric quarry sites, and one which has in large part led to the lack of even descriptive analysis of quarry debris (Purdy 1984). The material is usually ignored, or at best is lumped into general categories such as waste material or crude flakes (Hatch and Miller 1985), chunks and slabs (Stewart 1987), or "hash and

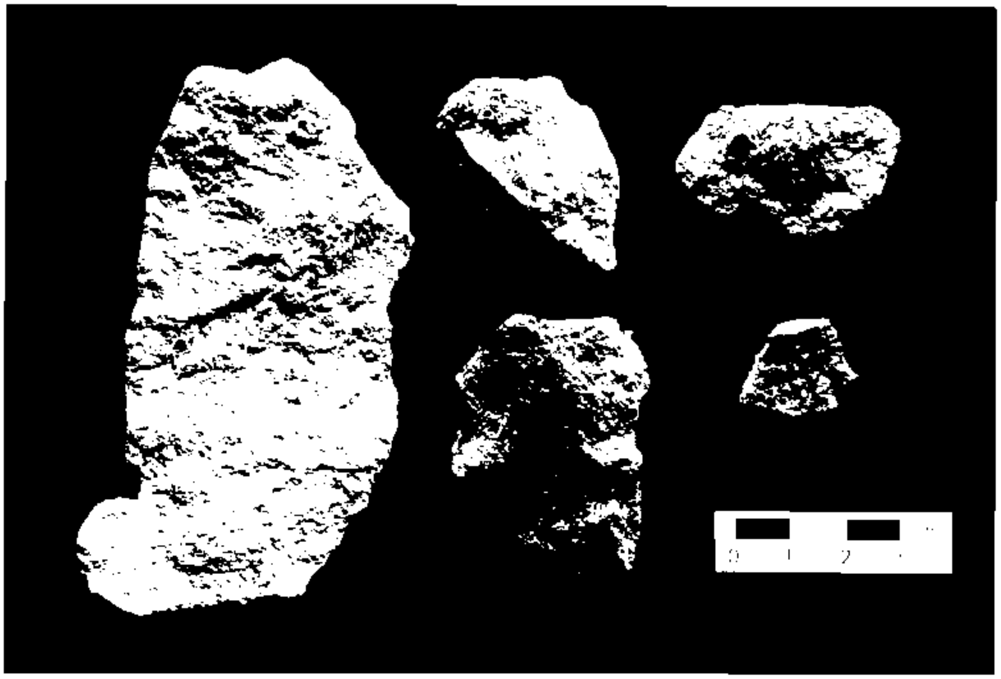


Plate 8-3. Siliceous Quarry Debris

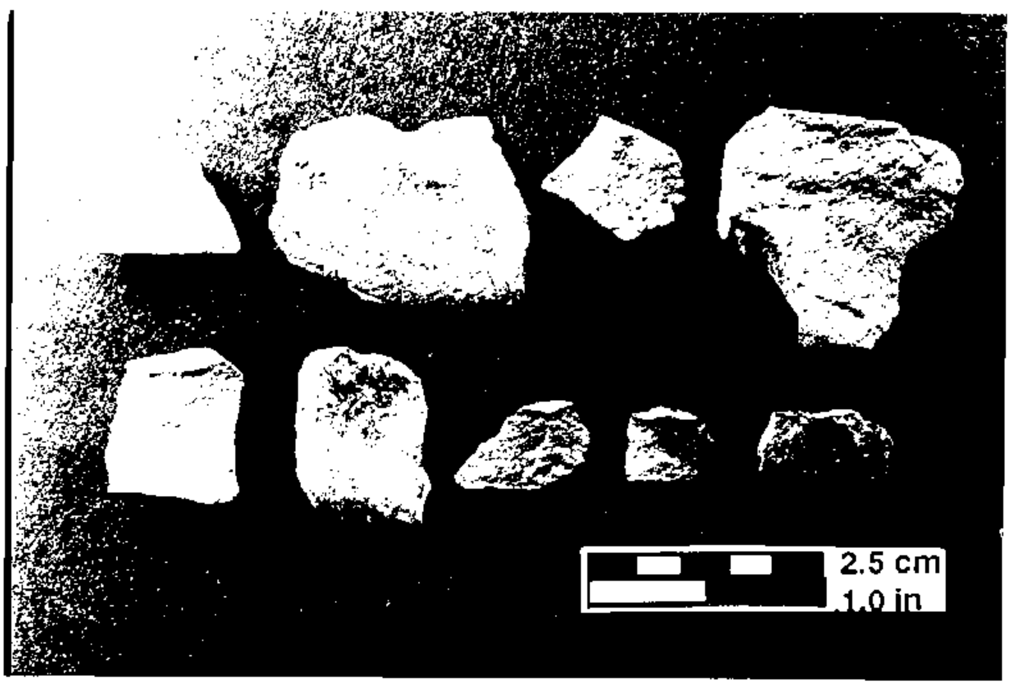


Plate 8-4. Jasper Flakes

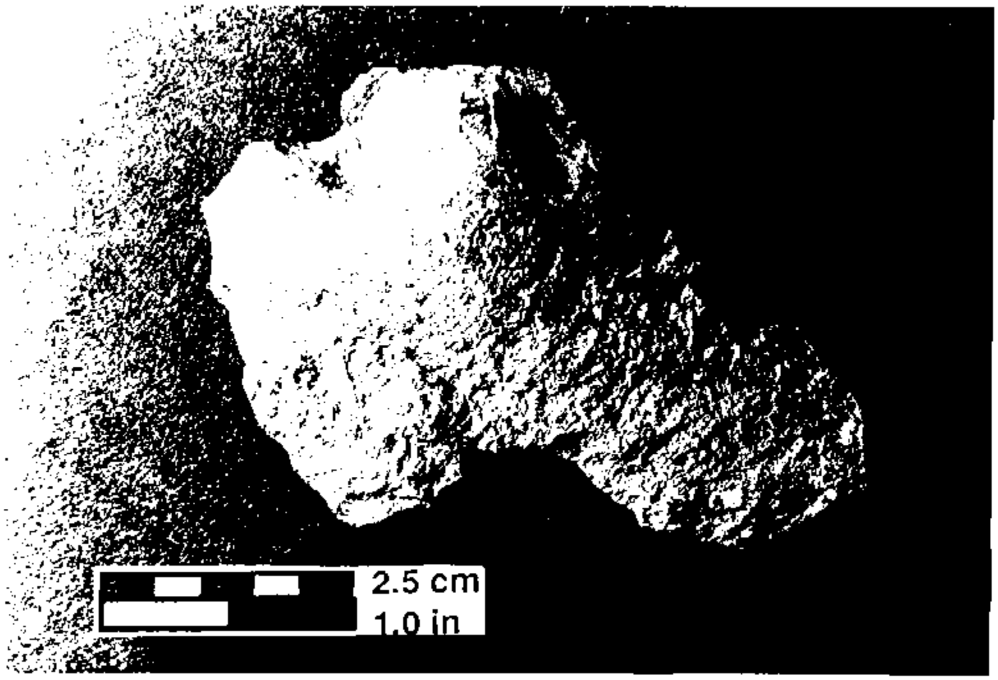


Plate 8-5. Jasper Flake

Plate 8-6. Size-Graded Debris

chunks" and "the detritus of bashing" (Carambelas and Raven 1991), and given no further consideration.

To confirm field judgments as to the artifactual nature of the debris recovered from the Iron Hill East site, casual experiments in reduction and heat treatment were conducted in conjunction with fieldwork. The reduction experiments consisted of the flaking of three blocks of limonitic material typical of the quality of lithic debris recovered at the site. The blocks were found within the existing right-of-way disturbance along SR 896. Hard hammer percussion was used to break open the blocks in search of material suitable for tool manufacture. No such material was found within the blocks, but an early stage biface was made from one of the resulting cores. The replication data suggested that much of the debris observed in the excavations at Iron Hill East was in fact cultural in origin. However, the fracture mechanics suggested that many such pieces would share attributes with natural spalls of the same raw material.

An informal experiment in heat alteration was also conducted, using debitage from the reduction experiments. Within 10 minutes of heating in a gas oven at 450 degrees Fahrenheit, the color of the material turned from brown to red. Due presumably to water trapped within the porous stone, the biface fractured entirely. The resulting spalled material resembled small pieces of fire-cracked rock rather than the fragments of a biface. The most significant result of the experiment was that a color change was effected in the material in a relatively short period of time and at relatively low temperatures (cf. Purdy 1981:123; Schindler et al. 1982:528). The implication drawn was that either natural and culturally induced burning could account for the reddening observed on the jasper and limonitic material from the site. In the end, these preliminary and informal experiments in reduction and heat treatment suggested that some degree of uncertainty can be expected in distinguishing between natural and cultural debris at the site in individual cases.

Size-Grade Analysis of Lithic Debris

Procedures. To more closely investigate the nature of the debitage across the project area and to assist in interpreting the range of knapping technology implied, Ahler's (1986, 1989) flake aggregate analysis, or mass analysis, was adapted for use with the Iron Hill East database. Mass analysis consists of the grading of debitage according to established size intervals, referred to as size-grades, and the retrieval of various quantitative data from each grade. These data are then subjected to a variety of statistical manipulations to yield results relevant to the type or types of reduction activity represented by the assemblage. Various analyses based on similar interval data have been conducted (see, for example, Gunn et al. 1976; Henry et al. 1976; Johnson 1981; Stahle and Dunn 1984; Patterson 1990; Petraglia et al. 1993; Riley et al. 1994a; Shott 1994). Ahler's work appears to be the most comprehensive and best documented study thus far undertaken, and so provides the greatest potential for inter-assemblage comparability. His methods and comparative data are used in the present study. The published data set consists of material derived from replication experiments using flint from the Knife River quarries in North Dakota (Ahler 1986, 1989). Following the initial comparative analysis using Ahler's original data, additional analyses were conducted using experimental and archaeological data sets from quarry and quarry-related sites in Virginia (Petraglia et al. 1990; Petraglia et al. 1993), and archaeological data from a range of site types in northern and central Delaware (Riley et al. 1994a).

Mass analysis entails quantifying several intuitive concepts associated with lithic reduction. The primary notion is that because lithic tool manufacture is a reductive process, both the tool and the debitage produced become smaller as the process continues. In short, debitage from later reduction stages should be smaller than that resulting from earlier stages, thus reflecting the diminishing size of the tool and the variation in load application (the amount of force applied, its location relative to the edge of the tool, and the angle of attack). In addition, there should be an observable progression in the removal of cortex during the reduction sequence, with later reduction stages producing on average less cortical material.

The sorting debitage samples by size intervals is accomplished by passing the samples through a series of screens with mesh openings of diminishing size. The process produces groups of material of consistent dimensions, referred to as size-grades. The size-grades and corresponding mesh opening dimensions used in the current study are equivalent to those employed by Ahler (1986:46). As noted previously, grading was accomplished in practice using circular templates to mimic the screening process. The diameters of each template corresponded with the hypotenuse of the appropriate screen mesh. Correspondences are listed in Table 8-4. A sample of size-graded material is illustrated in Plate 8-6.

Table 8-4. Comparison of Size-Grade Intervals

Size-grade	Screen Mesh Opening	Hypotenuse/ Template Diameter
0	5.1cm	7.2cm
1	2.5cm	3.6cm
2	1.3cm	1.8cm
3	0.6cm	0.8cm
4	0.3cm	0.4cm

Several simple count and weight measurements were then taken for each graded sample, and relative counts within and between size-grades were determined. Weight is considered a good overall indicator of artifact size (Magne and Pokotylo 1981), while weight variation within a size-grade becomes a measure of artifact shape—heavier flakes of the same size-grade will tend to be thicker. The data may then be used in differentiating between types of load application and by implication, the manufacturing technique: for example, between thin, marginal flakes characteristic of biface thinning, and relatively thick, non-marginal flakes characteristic of core reduction. The frequency of cortex within each size-grade is another important variable recorded in mass analysis. In the present case, cortical frequency data were considered inappropriate, since most of the debris from the site was by strict definition non-cortical, derived from interior portions of the jasper formation and thus bearing no weathered surfaces.

Reduction Stages. For analytical purposes, lithic reduction is viewed as a staged process, with the most complex product derived from the procedure being the bifacial tool form. Dividing the manufacturing sequence is somewhat arbitrary in that the stages identified are actually little more than signposts, as opposed to fixed, intermediate levels of production. Yet the sequences described by staged models represent useful devices for organizing data into standardized categories, and thereby providing a basis for both intrasite and intersite comparative analyses. Table 8-5 lists the reduction stages employed in Ahler's Knife River experiments and used in comparative analysis with the Iron Hill East material. Hard Hammer Cobble Testing [HHCT] refers to the initial flaking of a cobble or core in evaluating the quality of the raw material. Random Flake Production [RFP] is the only category that is not necessarily a stage in a typical biface reduction sequence, but rather refers to a process in which the detached flakes, and not the core, are the primary product. Hard Hammer Stage 2 [HH-2] refers to the initial creation of a bifacial edge on a cobble or blocky core, and typically results in the detachment of relatively large flakes in a patterned manner. Hard Hammer Stage 3/4 [HH-3/4] entails efforts at thinning the biface, and produces large flakes that are thinner than those resulting from HH-2.

Table 8-5. Reduction Stages Used in Knife River Experiments

HHCT	Hard Hammer Cobble Testing
RFP	Random Flake Production
HH-2	Hard Hammer Stage 2, Initial Edging
HH-3/4	Hard Hammer Stage 3/4, Thinning

Comparative Analysis. The purpose of the analysis in the present case was to determine 1) whether the material from Iron Hill East is comparable in character to that from other quarry locales; 2) what reduction technology or technologies are implied by the comparison; 3) whether there is any intrasite variation or potential for the differential distribution of material, which might signal different activity areas and thus by implication horizontal integrity across the site area.

Flake size data from each of the six 1m^2 test units were analyzed, along with data from two shovel test proveniences: the single shovel test at N330 E240, which lay adjacent to Unit 4 and contained a relatively large sample of 35 artifacts; and four shovel tests centered around N200 E210[†], which lay adjacent to Unit 1 and comprised a combined sample of 51 artifacts. Analysis by provenience of the frequency (percentage of the total debitage count per provenience) of each size-grade is summarized in Table 8-6. Bivariate plots of the data were constructed and are illustrated in Figure 8-9.

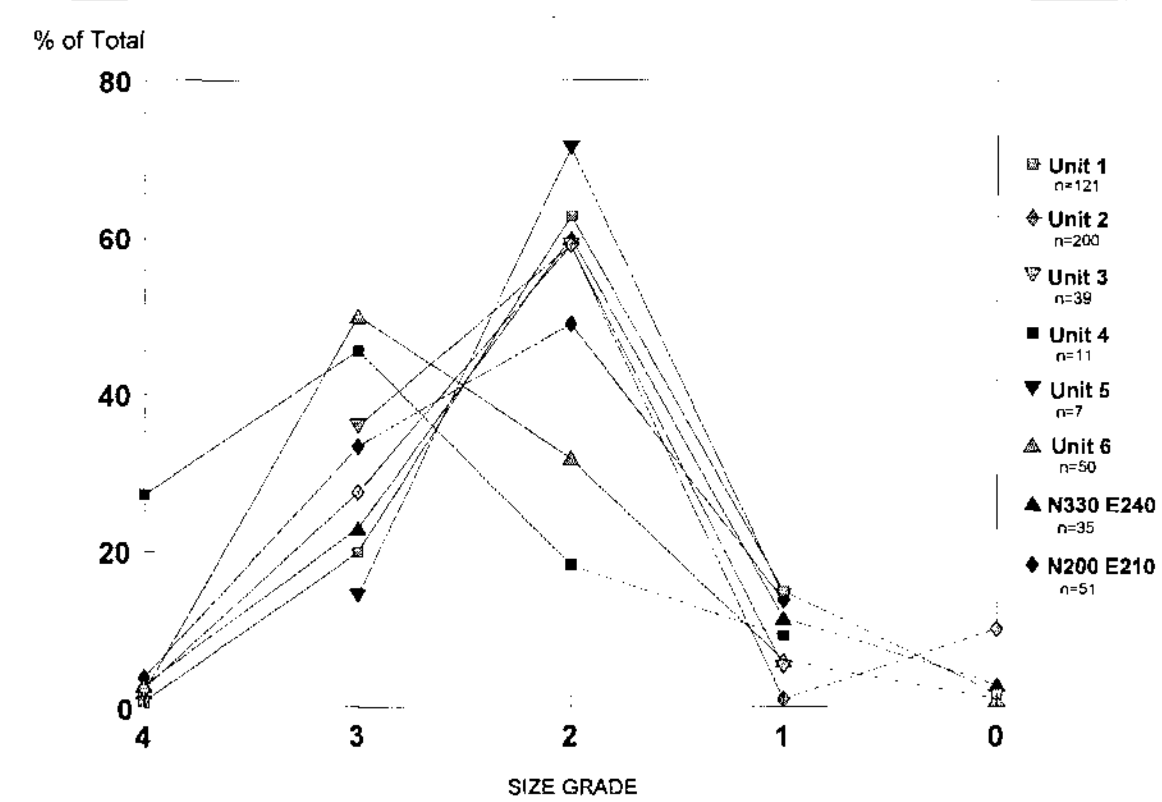


Figure 8-9. Iron Hill East: Size Grade Analysis for Selected Proveniences

† N200/E200; N200/E210; N200/E220; N210/E210

Table 8-6. Iron Hill East, Size-Grade Data

	Size-Grade	Count	Weight	Mean Weight		Size-Grade	Count	Weight	Mean Weight
Unit 1	0	2	754.8	377.4	Unit 5	0	0	0	0.0
	1	18	736.2	40.9		1	1	26.5	26.5
	1.5[†]	35	423.3	12.1		1.5	4	54.3	13.6
	2	41	232.5	5.7		2	1	3.1	3.1
	3	24	39.3	1.6		3	1	2.1	2.1
	4	1	0	0		4	0	0	0.0
	Unit Total	121	2186.1	18.1		Unit Total	7	86.0	12.3
Unit 2	0	20	1217.1	60.9	Unit 6	0	1	192	192.0
	1	2	363.1	181.6		1	3	125.2	41.7
	1.5	48	684.3	14.3		1.5	5	118	23.6
	2	70	447.7	6.4		2	9	60.3	4.4
	3	55	122.4	2.2		3	25	32.3	1.3
	4	5	1.6	0.3		4	1	0.4	0.4
	Unit Total	200	2836.2	14.2		Unit Total	50	528.2	10.6
Unit 3	0	0	0	0.0	N330/E240	0	1	877.9	877.9
	1	2	210.3	105.2		1	4	455.9	114.0
	1.5	4	57.9	14.5		1.5	9	125.2	13.9
	2	19	88.6	4.7		2	12	71.8	6.0
	3	14	28.1	2.0		3	8	11.7	1.5
	4	0	0	0.0		4	1	1.3	1.3
	Unit Total	39	384.9	9.9		Unit Total	35	1543.8	44.1
Unit 4	0	0	0	0.0	N210/E210	0	0	0	0.0
	1	1	35.7	35.7		1	7	485.8	69.4
	1.5	1	21.1	21.1		1.5	11	127.2	11.6
	2	1	2.7	2.7		2	14	70.7	5.1
	3	5	6.4	1.3		3	17	23.8	1.4
	4	3	2.8	0.9		4	2	0.6	0.3
	Unit Total	11	68.7	6.3		Unit Total	51	708.1	13.9

[†] intermediate grade used later for comparison with UD/CAR database

Two repeated patterns occur among the data. Figure 8-10 shows the plots of the size-grade distributions from Units 1, 2, 3, and 5, along with the shovel tests at N330 E240 and N200 E210. Three of these proveniences lay south of the intermittent stream, while the shovel test at N330 E240 lay on the immediate north bank. Unit 5 lay on the south face of a wide, gently sloping interfluve, while Unit 3 lay near a series of ephemeral drainages at the north end of the project area. All of the proveniences display similarly patterned line charts, with the greatest proportion of flakes—from 51 to 71 percent—falling in size-grade 2.

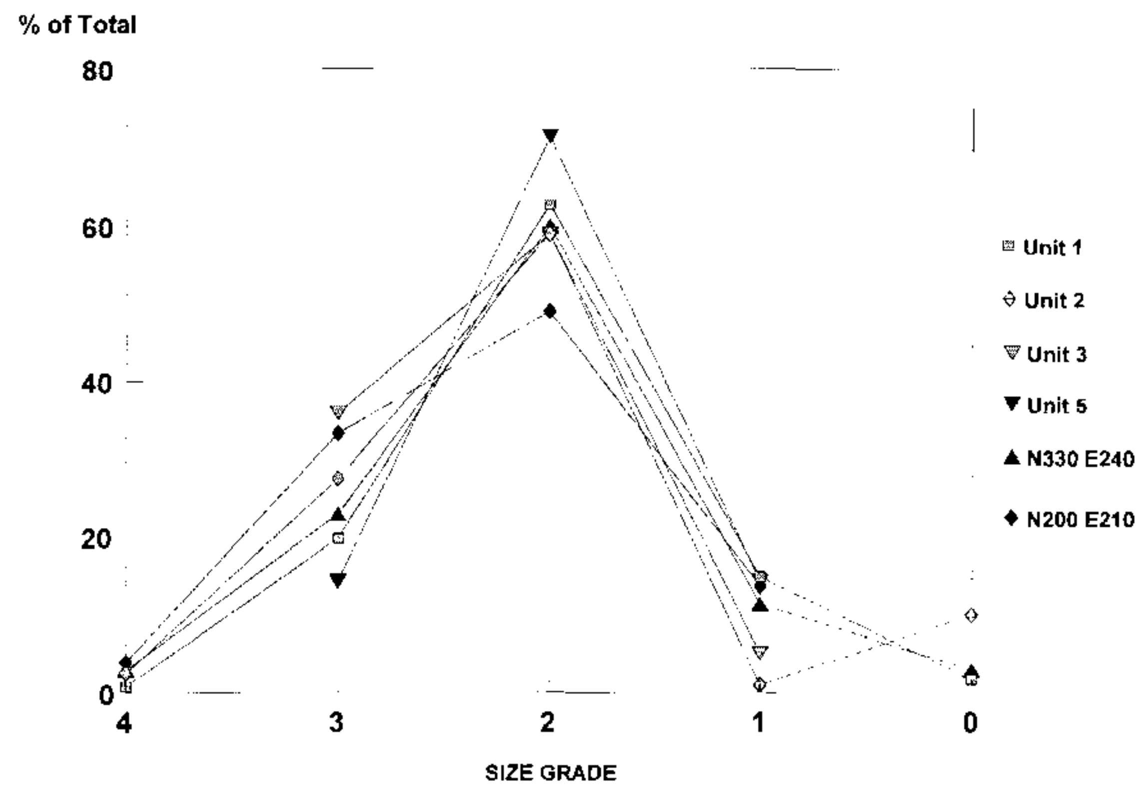


Figure 8-10. Iron Hill East: Size Grade Analysis, Grade 2 Peak

The plots from Units 4 and 6 (Figure 8-11), which lay north of the stream, exhibited characteristics that suggested both dissimilarity with other proveniences and some mutual consistency. In both cases, the debris was uniformly smaller than in other proveniences, with the highest proportion of material occurring in size-grade 3: 63 and

60 percent, respectively. It should be noted that the small sample size from Unit 4 (n=11) may render the data from that provenience less than reliable. The unit lay 5m north of N330 E240, and it was expected that the size distributions from the two proveniences would be similar. The majority of the debris from the larger sample from N330 E240, 64 percent, occurred in size-grade 2, consistent with most of the proveniences at the site, suggesting that the sample from Unit 4 may indeed have been biased.

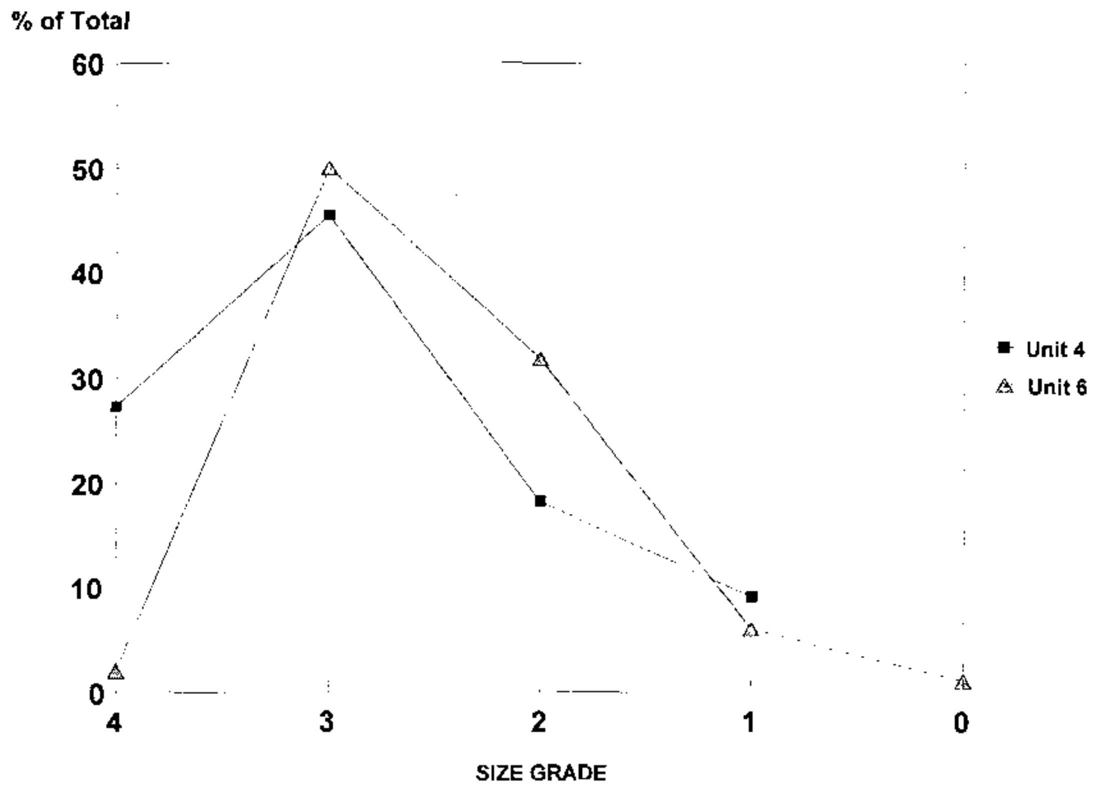


Figure 8-11. Iron Hill East: Size Grade Analysis, Grade 3 Peak

Cumulative frequency distributions, were constructed for comparison with Ahler's Knife River experimental data. Two measures were plotted: the percentage by count represented by each grade and the percentage by weight. Only three grades were used in the analysis. Data for size-grade 0 were not separated from size-grade 1 in the Knife River material, and thus grades 0 and 1 from Iron Hill East were combined as size-grade 1. In addition, the smallest screen mesh opening used in the field at Iron Hill East was

1/4-inch, which corresponds with size-grade 3 (0.6cm). Debris below this size was not systematically captured, and thus size-grade 4 is an incomplete sample and could not be used for direct comparison.

Figure 8-12 displays the percentage by count represented by each size-grade from 1 to 3 for the Knife River data set. Most of the debitage occurs in grade 3. Some differentiation can be seen in the curve of HHCT. There the proportion of flakes in size-grade 2 is greater than in the other curves, indicating the presence of more large debitage, which is not unexpected for a knapping procedure in which the removal of large flakes is necessary in order to examine raw material quality. In contrast, the curve of SH-3/4 shows the lowest proportion material in size-grade 2, indicating the production of more small material.

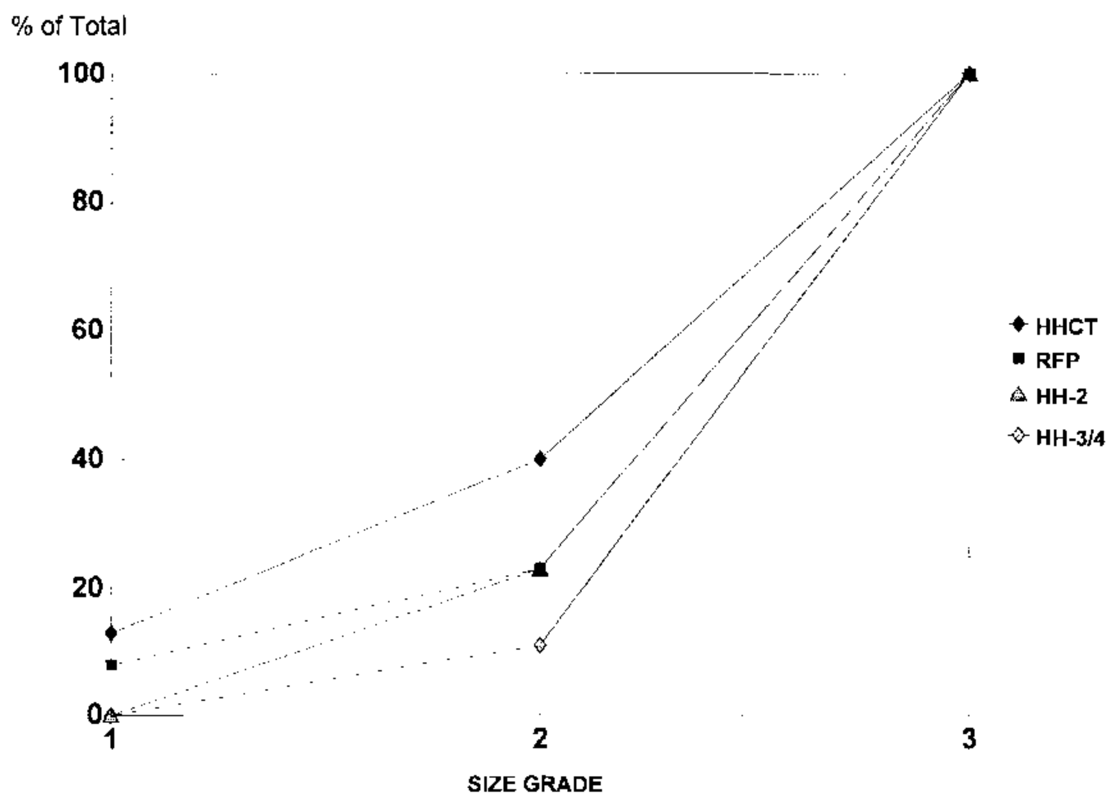


Figure 8-12. Knife River Experimental Data: Cumulative Frequency Distribution by Count

In Figure 8-13, count data from Iron Hill East are added. The separation between the Iron Hill and Knife River curves is pronounced. For each Iron Hill provenience, the largest number of pieces occurs in grade 2. And in every case the percentage is substantially higher than for the Knife River samples, indicating that the Iron Hill East material is, on average, larger. There is little differentiation displayed between the Iron Hill East proveniences, except in the case of Unit 6, which displays an inflection at size-grade 2 resembling the Knife River curves, and in fact matches the curve for HHCT at that point. The implication is that the knapping technology represented by the debris from Unit 6 was different from that in the remainder of the site. The degree to which it correlates with the biface reduction data from Knife River will be considered further.

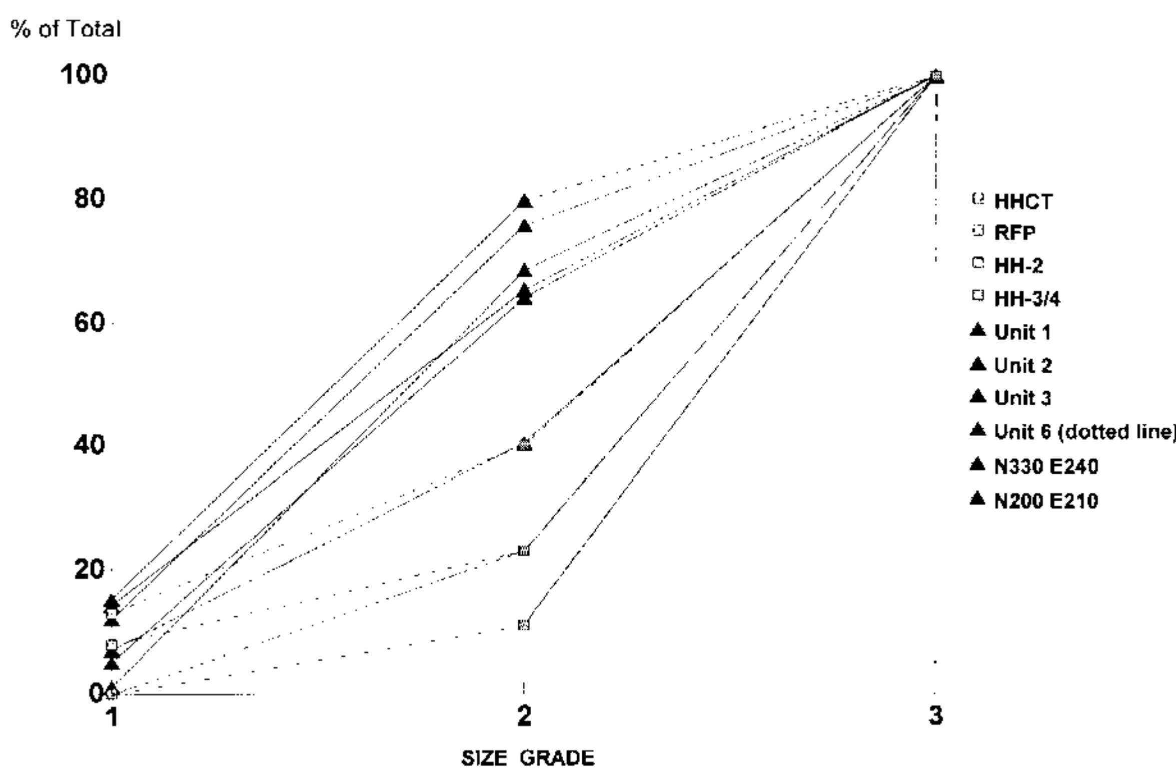


Figure 8-13. Iron Hill East : Cumulative Frequency Distribution by Count

The frequency by weight over size-grades 1-3 for the Knife River data set is shown in Figure 8-14. Mirroring the count distribution from that data, most of the weight of the Knife River debitage is contained in size-grade 2. Separation can be seen in the curve for SH-3/4, indicating that more small, thin flakes were produced during the thinning process. Figure 8-15 illustrates comparative data from Iron Hill East. Much more of the weight of the Iron Hill material is contained in the size-grade 1 debris, with from 54 to 86 percent of the total weight occurring in that size interval, in contrast to a range of 4 to 42 percent for the Knife River data. That is, most of the debris from Iron Hill East is large and heavy compared with the Knife River experimental material.

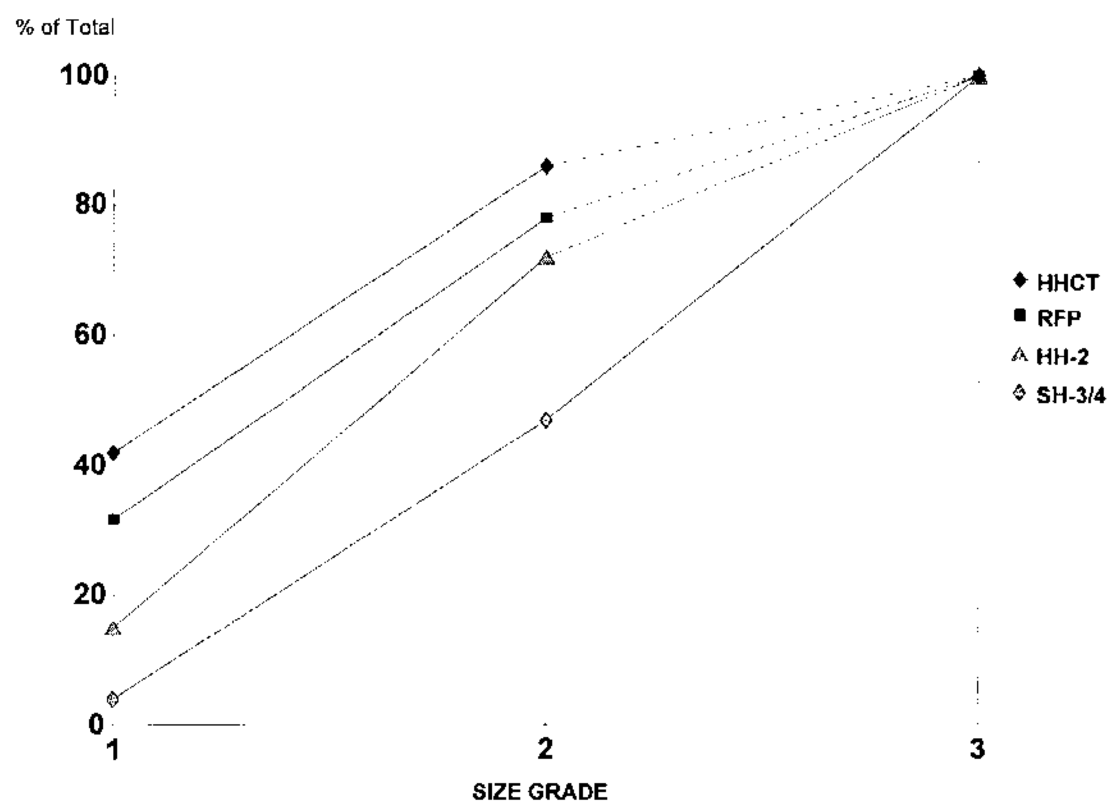


Figure 8-14. Knife River Experimental Data: Cumulative Frequency Distribution by Weight

While some difference between the material from Unit 6 and the rest of the Iron Hill East site may be evident, direct analogy between that provenience and the Knife River data is not supported by the cumulative distribution graphs. Count data were similar, but weight data suggested a substantial difference. The material from Unit 6 at

Iron Hill was heavier than the debitage from Knife River, with the mean weight of flakes from Unit 6 calculated as 10.6gm. In contrast, the greatest mean weight calculated from the Knife River data was in the HHCT category, 6.9gm, the next greatest from the RFP category, 2.6gm. The implication is that the Iron Hill material is thicker and more blocky, suggesting that biface manufacture was not the primary focus of lithic reduction activity. Whether or not the data imply that some biface reduction was carried out (i.e., some initial edging) is unclear, since the preceding analysis cannot support such a conclusion.

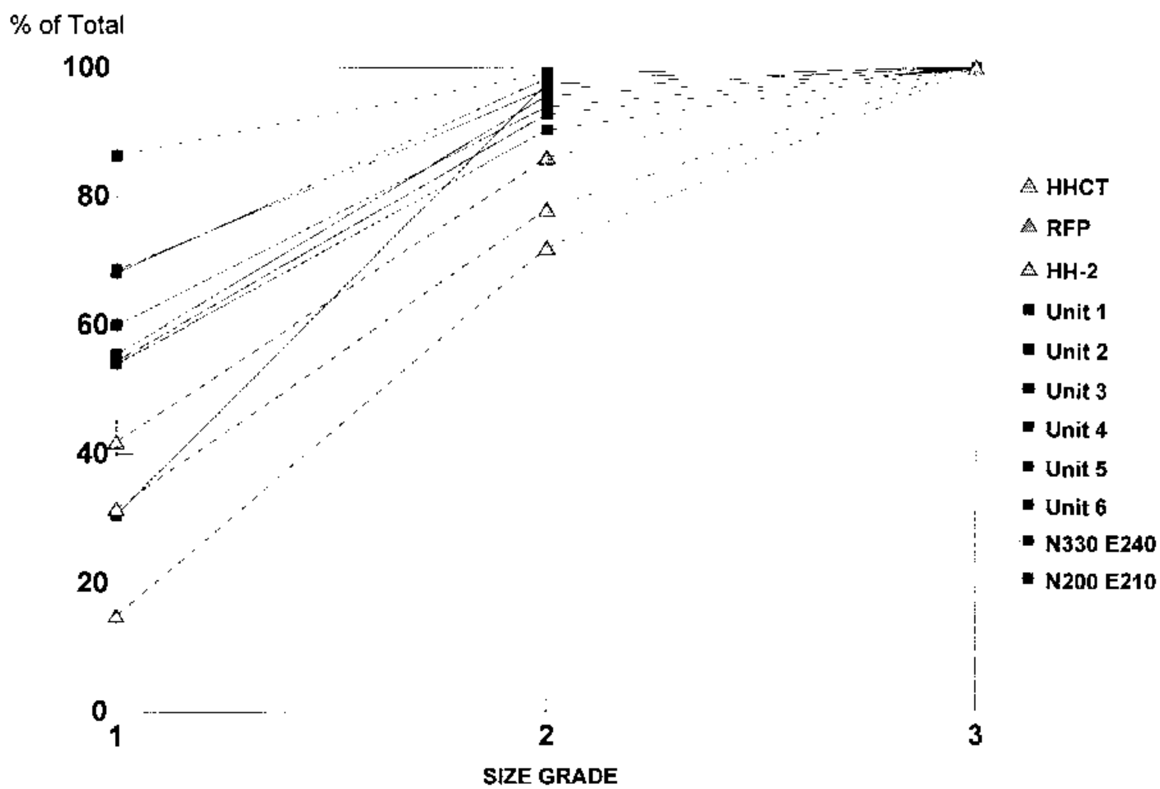


Figure 8-15. Cumulative Frequency Distribution by Weight, Iron Hill East and Knife River Experimental Data

Alternative Data Sets. Size-graded data from investigations at a series of sites in the Piedmont of northern Virginia (Petraglia et al. 1993) were also used for comparative analysis. The archaeological data from the Virginia study consisted in part of cumulative frequency distributions of size-graded debitage from site 44PW592, a site of indeterminate age at which secondary deposits of quartz cobbles were quarried. A series of replication experiments, focused on quartz cobble reduction, were also conducted as part of the study. The experimental replications conformed to typical staged reduction sequences, similar to those used in the Knife River database. The stages most applicable to the Iron Hill analysis were the initial stages, Free Hand Cobble Reduction [FHCR] and Primary Thinning [PT]. Debitage from the replications and from the archaeological proveniences was passed through nested screens with dimensions equivalent to the mesh openings used at Knife River for comparability (Table 8-4).

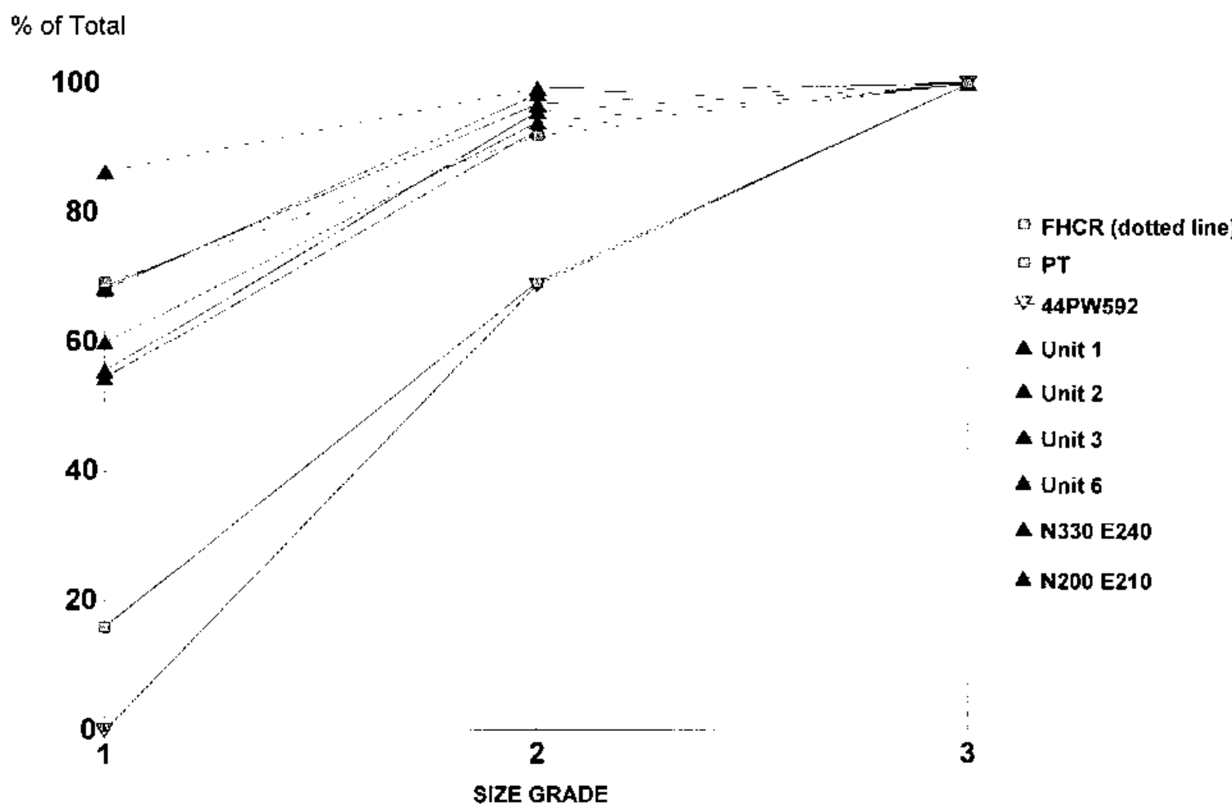


Figure 8-16. Cumulative Frequency Distribution by Weight: Iron Hill East and Virginia Experimental and Archaeological Data

Percentage by count over grades 1-3 for both the Virginia experimental data and site 44PW592 are displayed in Figure 8-16, along with data from Iron Hill East. The three Virginia curves all bear the same inflection at size-grade 2 seen in the Knife River data, indicating that most of the flakes in the distribution are small. Such a curve occurs repeatedly in experimental distributions, and thus appears typical of even the earliest stages biface reduction. As seen in Figure 8-17, Unit 6 displays a similar curve. In contrast, the plot of percentage by weight for the same data is less clear-cut. The distributions for 44PW592 and the experimental PT category are similar and well

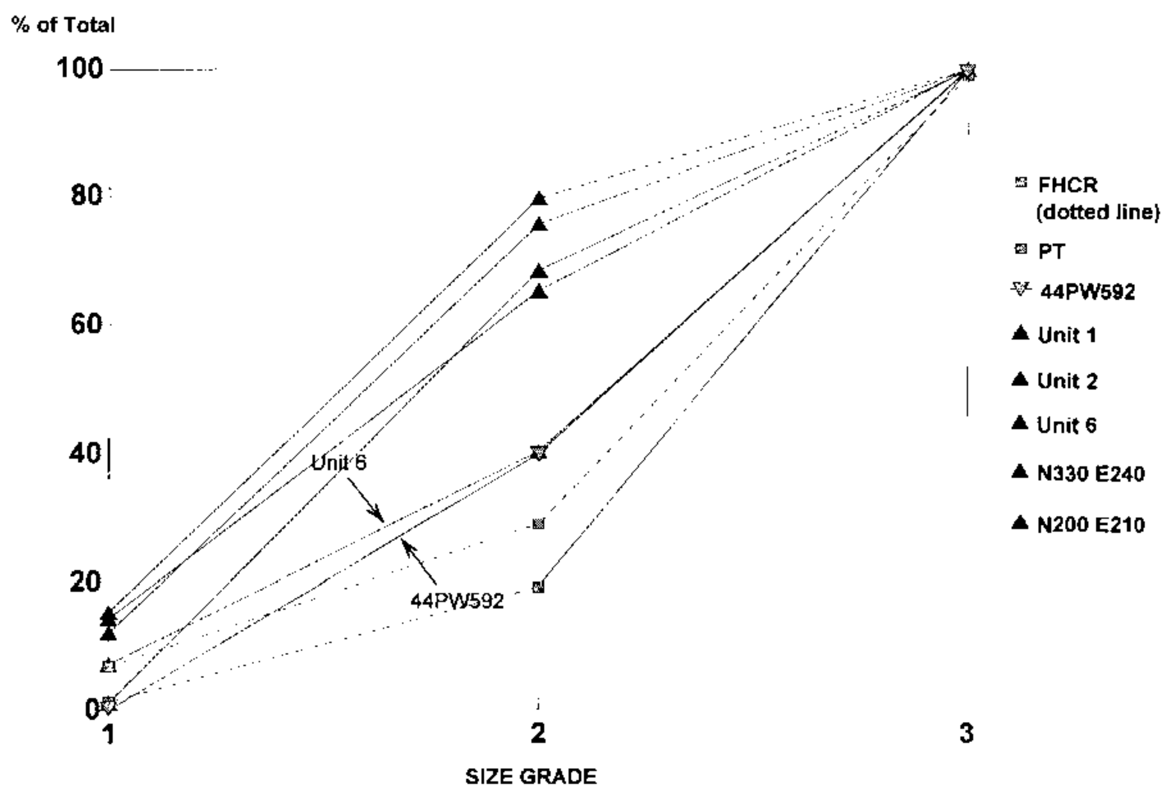


Figure 8-17. Cumulative Frequency Distribution by Count: Iron Hill East and Virginia Experimental and Archaeological Data

separated from the Iron Hill data. In contrast, the curve for FHCR lay within the range of the Iron Hill curves. In both cases, the knapping characteristics of quartz appear to be an important factor in the form of the distribution curves. That is, quartz typically exhibits many flaw planes, and as a result, percussion flaking tends to produce a greater percentage of both large chunks and small fragments, or shatter, than are generated during the knapping of cryptocrystalline lithic materials such as jasper.

A slightly different form of size grading has recently been employed with some success by the University of Delaware, Center for Archaeological Research [UD-CAR] in analyses of archaeological data recovered from a range of site types in northern and central Delaware (e.g., Riley et al. 1994). The UD-CAR analyses use a similar series of templates consisting of circles of fixed diameter to grade debitage. An intermediate grade appears in the UD-CAR data, falling between size-grades 1 and 2. It has been recorded in the present study as size-grade 1.5 (Table 8-6). In addition, the UD-CAR system assigns size-grades upward. That is, in contrast to most size grading schemes, in which artifacts larger than a given template or mesh opening are assigned the number of that grade, the UD-CAR system assigns the artifact to the next highest grade. The correspondence between the UD-CAR templates and the system used in the present study is summarized in Table 8-7.

Table 8-7. Size-Grade Interval Comparison: Iron Hill East and UD/CAR Analyses

Size-Grade	Screen Mesh Opening	Hypotenuse	UD-CAR Template #	UD-CAR Template Size Opening
0	5.1cm	7.2cm	n/a	n/a
1	2.5cm	3.6cm	V	4-5cm
1.5	1.3cm	1.8cm	IV	3-4cm
2	n/a	n/a	III	2-3cm
3	0.6cm	0.8cm	II	1-2cm
4	0.3cm	0.4cm	I	<1cm

Size-grade distributions from each of the Iron Hill East proveniences were replotted using the intermediate size-grade 1.5. A slightly more complex pattern is brought out at this level of resolution, although the same two general curves remained evident. Figure 8-18 illustrates the distribution of material in all size-grades for Units 1, 2, and 5, and N330 E240 and N200 E210. The plot from Unit 5 is the most eccentric, bearing a shape dissimilar to those of the remaining proveniences. As in the case of Unit 4, small sample size (n=7) may be the most significant factor influencing the shape of the plot, rather than an actual difference in knapping technology—the possibility of biased data in such a small sample is high, and thus the pattern was not given further interpretive consideration.

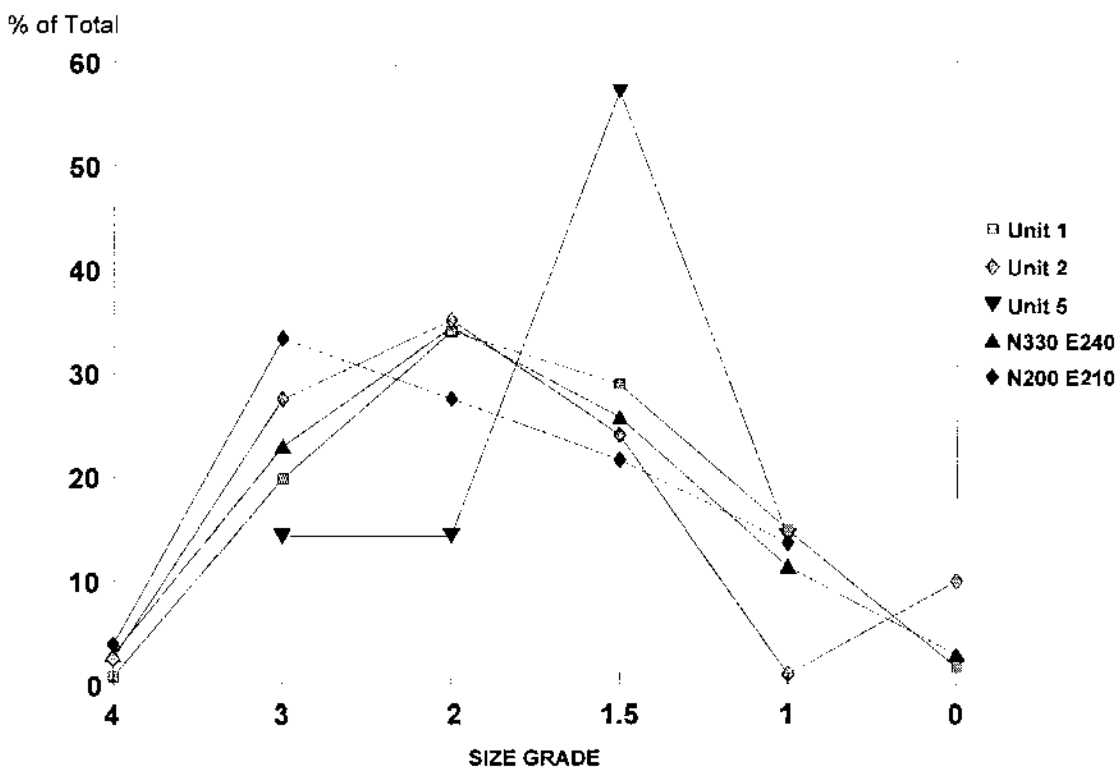


Figure 8-18. Iron Hill East: Size Grade Analysis Using Intermediate Grade (1.5)

The plots for the remaining four proveniences are mutually similar, with the greatest proportion of debris occurring in grade 2, and lesser but roughly equal amounts in grades 2 and 1.5. The size distribution from N200 E210 is less well-matched with the other three, with the proportions of size-grades 3 and 2 reversed in comparison. The revised plots from Units 4 and 6, and in addition, Unit 3, are dissimilar to Units 1 and 2 and the shovel test proveniences (Figure 8-19). Again, the small size of the sample from

Unit 4 renders the data from that provenience suspect. There is little similarity between the curves from Units 3 and 6, suggesting no correspondence in the reduction technologies responsible for the debris in those units.

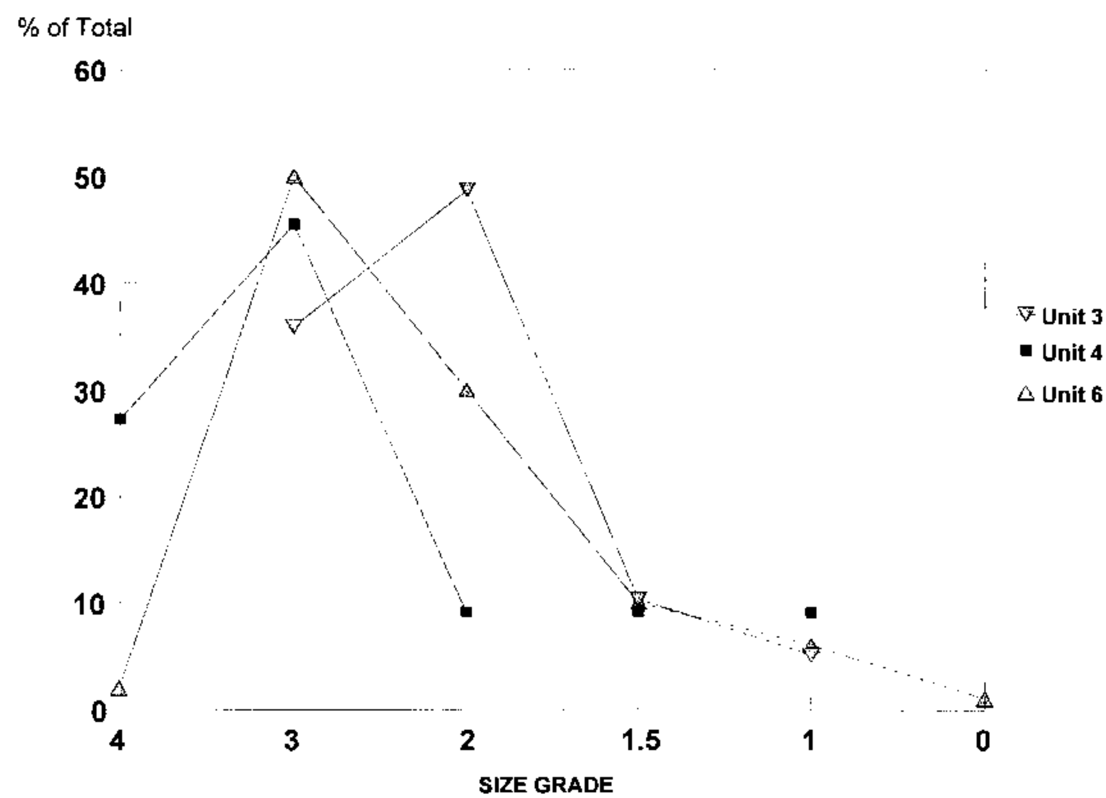


Figure 8-19. Iron Hill East: Size Grade Analysis Using Intermediate Grade (1.5)

The apparent complexity exhibited by the data in the plots using the intermediate size-grade may in fact be an artifice of the level of resolution. That is, a pattern may have been brought out in the data that has little to do with the behavior that produced the artifacts. Sample size may again be a factor, since the odd curves seem to be associated with the smallest samples, suggesting that one or two pieces at size-grade 2 or 2 may be influencing the shapes of the graphs from those proveniences. Experimentally derived data, which are not presently available, would be a useful addition to the database.

In terms of answering the original questions asked of the analysis: 1) comparison with other quarry locales—there is in the end little directly comparative data, only a series of experimental data sets, of which two were employed here and which focus on biface reduction, not on quarrying debris; 2) implications for reduction technologies—based on these comparative analyses, little or no biface reduction was evident at Iron Hill East, except possibly in the area around Unit 6; 3) intrasite artifact patterning—little distributional variation was observed among the data, suggesting a relatively low potential for differentiating activity areas across the site, and supporting a conclusion that the site exhibits little horizontal integrity.

To further investigate the potential for significant differences between the material from Unit 6 and that from the remainder of the site, the ratio of small to large flakes from each provenience was calculated. Count ratios are used in mass analysis as an alternative means of differentiating reduction stages. Typically, comparison is made of the frequency of grade 4 debris and the frequency of material in grades 1-3. Because grade 4 is incomplete in the present samples, the ratio of grade 3 to grades 0-2 was used. The ratios are displayed in Table 8-8. The ratio is considerably higher for Unit 6 than for the other proveniences, indicating that there were more small fragments in that unit. By implication, the material represents a different type of reduction strategy.

Table 8-8. Iron Hill East: Ratio of Small to Large Debris

Provenience	Grade 3:Grade 0-2
Unit 1	0.3
Unit 2	0.4
Unit 3	0.6
Unit 6	***1.4***
N330 E240	0.3
N200 E210	0.5

While direct comparison with UD-CAR data could not be undertaken, since raw figures on size-grade distributions have not been published, a small database using linear regression and semi-log plots of the northern and central Delaware data has been produced (Riley et al. 1994: Figure 139, 140). An attempt was made at comparative analysis using this material, and the results are described below.

Log-Linear Modeling. The UD-CAR graphs are based on Patterson's (1990) logarithmic transformations of flake size distributions. Patterson uses experimental and archaeological data sets to demonstrate that biface reduction produces a distinctive concave curve when flake size interval frequencies are plotted on a simple linear graph (Figure 8-20a). He goes on to observe that a semi-log plot of the same data, with size intervals plotted on a linear scale and frequency on a logarithmic scale, results in a straight-line curve or log-linear regression with a negative slope (Figure 8-20b). Shott (1994), in a review of the current status of flake analysis in North American archaeology, takes the further step of plotting several additional sets of published experimental data on the same set of axes. He notes that there may be a direct relationship between the slope of the line and the reduction stage, with steeper slopes associated with later reduction stages.

As indicated by Figure 8-21, none of the distributions from the Iron Hill East proveniences as plotted on simple linear graphs exhibited the concave distribution Patterson recognized as characteristic of biface reduction. Direct comparison with Patterson's data on an interval by interval basis is impractical—the two data sets cannot easily be placed on the same pair of axes since the data are reported at different scales. One potentially significant difference between Patterson's distribution and that developed in the current study is that Patterson ignores debitage measuring less than 1cm, equivalent to size-grade 3 and below in the present analysis. Shott's (1994:91-94, Figure 1-4) use of Patterson's distribution on other experimental data sets, specifically those of Behm (1983) and Tomka (1989), employs an interval range that encompasses smaller flake sizes (the current size-grade 4 and below). Shott's results tend to confirm Patterson's overall findings, although he does caution that the available data sets are limited. He notes that there are inconsistencies that will require more experimental work to fully

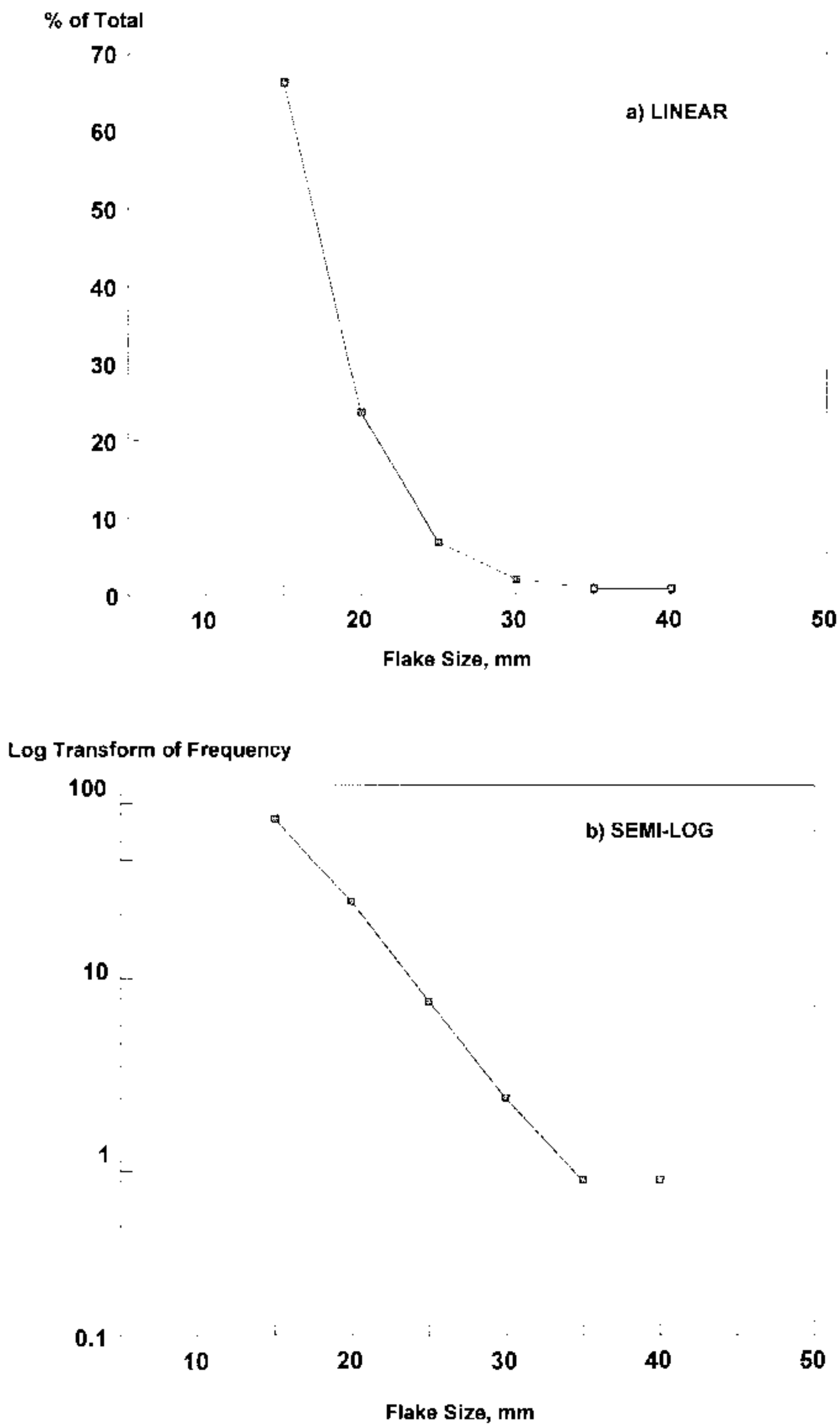


Figure 8-20. Patterson's Experimental Biface Reduction Flake Size Distribution

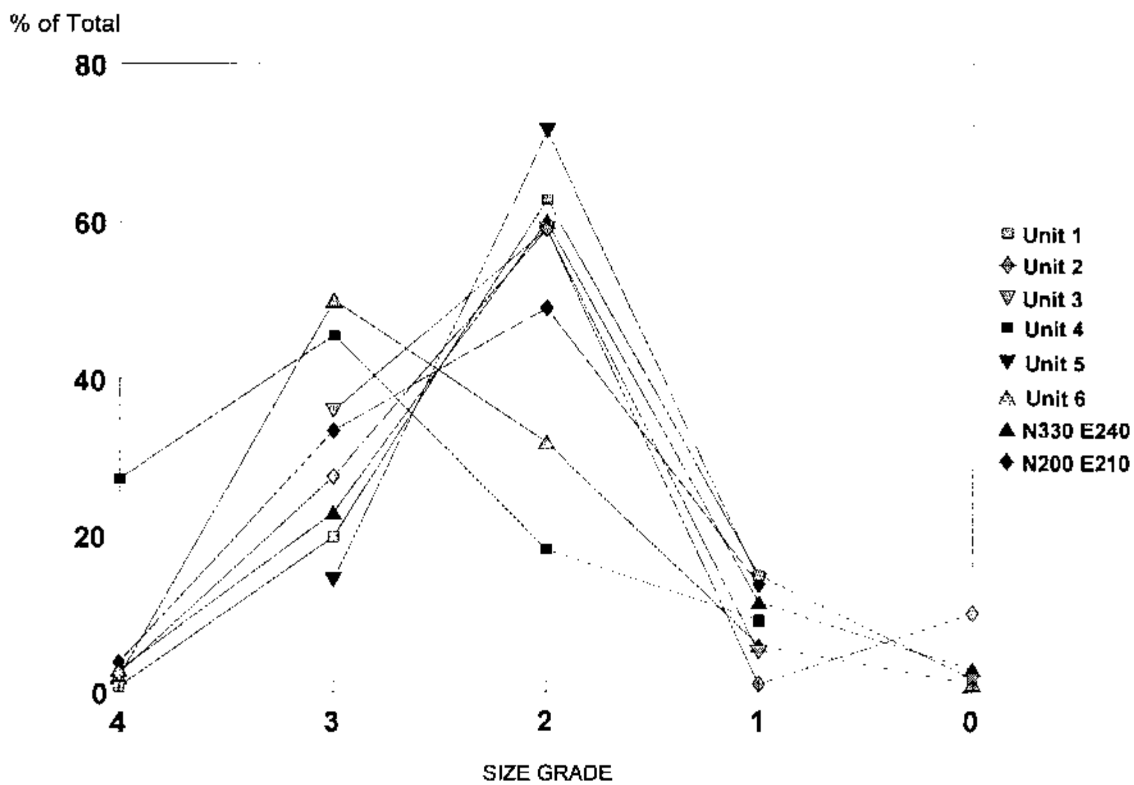


Figure 8-21 Iron Hill East: Linear Plot of Size Grade Data

understand. For present purposes, though, the procedure appears useful in indicating the divergence of the Iron Hill East debris from the pattern typically associated with biface reduction.

Semi-log plots of material from the Iron Hill East proveniences (Figure 8-22) indicate little evidence that biface reduction was carried out within the site area. Only two provenience, Units 4 and 6, approach the log-linear distribution described by Patterson. As noted earlier, the sample size from Unit 4 makes it liable to bias from unusual individual items, and thus the sample is in effect unreliable. Unit 6 comprises a larger and presumably more representative sample. The size-grade distribution from that unit displays a relatively close fit to Patterson's model, suggesting that the debris may include the remains of biface reduction.

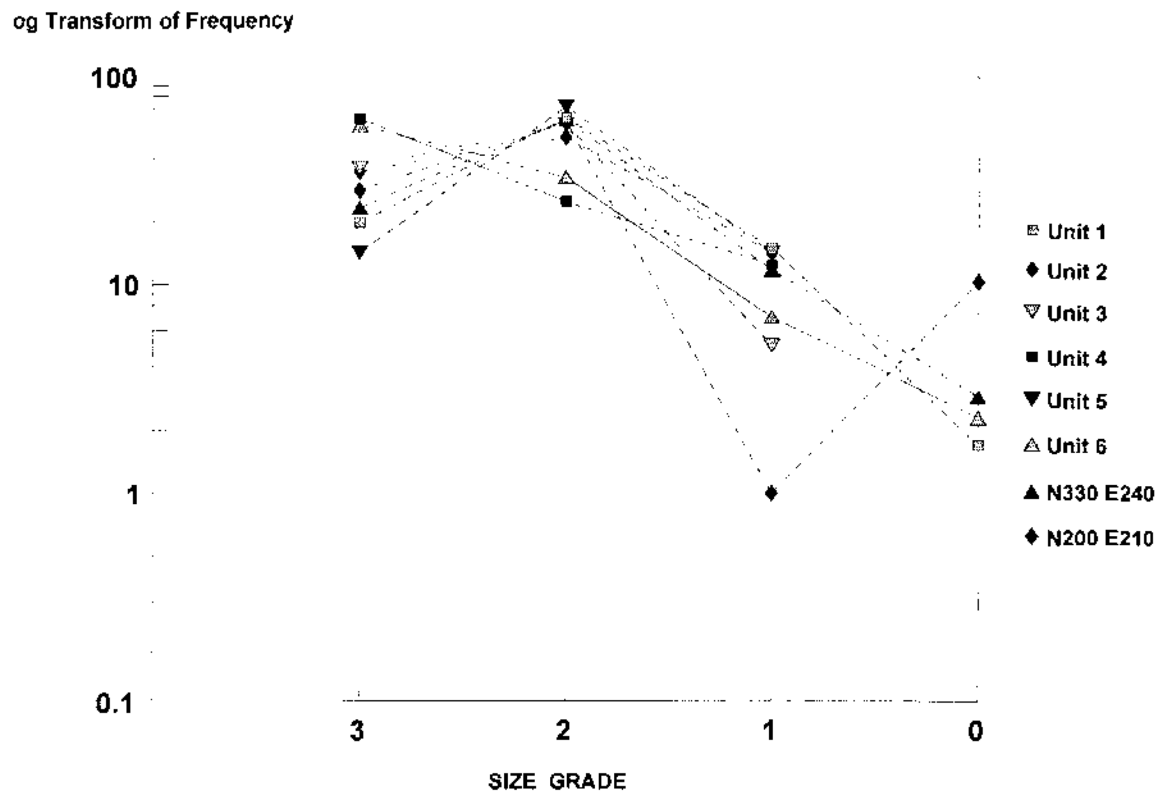


Figure 8-22. Iron Hill East: Semi-Log Plot of Size Grade Data

In the end, comparative analysis using the UD-CAR data (Riley et al. 1994a) was problematical. The published graphs appear to represent linear regressions of the size distribution data, rather than logarithmic transformations. In the presentation, the plots of 12 sites or site components are presented, and several observations are made based on the slopes of the regression lines. It is noted, to begin with, that each site has a distinctive slope, whereas a normal distribution of slope values was expected. Secondly, it is stated that the regression lines from each of the sites display negative slopes, indicating the presence of more small than large flakes in the distributions. Quarry sites, it is noted, should display positive slopes, indicating more large than small flakes. A final observation concerns an apparent positive relationship between site location and flake size distributions; that is, the farther north a site occurs in Delaware, the greater the percentage of small flakes present.

While data from the present investigation cannot directly address each of these points, some comments are in order. In response to the first item, there may in fact be a normal distribution of slopes, but the sample reported is small enough that it may not be representative. Moreover, a direct relationship between site function and the slope of a regression line based on flake size distributions is probably a simplistic assumption. Much more sophisticated models of debitage characteristics and site use have been formulated and have been unable to demonstrate absolute or categorical associations (Raab et al. 1979; Magne 1985; Shott 1994).

Table 8-9. Iron Hill East: Linear Regression Statistics for Size Distribution of Lithic Debris

Provenience	*b* coefficient	r^2
Unit 1	-5.5	0.48
Unit 2	-6.9	0.63
Unit 3	-13.1	0.66
Unit 4	-10.9	0.60
Unit 5	4.3	0.07
Unit 6	-12.2	0.90
N330 E240	-6.3	0.65
N200 E210	-6.5	0.99

Regarding the second item, the data from Iron Hill East (Table 8-9) suggest that the opposite is true—like most sites, the regression line of debitage size-distribution from a quarry site will display a negative slope. In all but one instance, the *b* coefficient, which represents the slope of the regression line, is negative (note that the incomplete size-grade 4 was omitted from the analysis). The slope calculated for Unit 5 is positive, but problems with sample size and representativeness associated with that unit have previously been indicated, and in fact, a low coefficient of determination, r^2, from the unit emphasizes the non-representative nature of the material. In sum, the data from Iron Hill East suggest that, as is the case with other site types, the slope of the line resulting from the regression of debris size distribution at a quarry site may be expected to be negative.

The most valid observation stemming from the analysis may concern the relationship between steepness of the regression line and the reduction stage represented by the debris. Shott (1994) noted that the steepness of the plot resulting from Patterson's semi-log transforms of size distribution data appeared to be related to the reduction stage represented. A similar situation may hold for the debris from quarry locales—size distribution slopes may be slightly flatter on average than those from sites where late stage reduction was a major focus of activity. This would in fact confirm the UD-CAR researchers' observation that a higher frequency of large debris would be expected at a quarry site on than a site at which tool maintenance was the main lithic reduction activity. Based on the analyses thus far conducted, it is assumed that quarry-related reduction was the main, if not the only lithic reduction activity conducted at the site. Yet the slopes of regression lines from the several proveniences are relatively steep, as indicated in Table 8-9 and Figure 8-23. Some degree of difficulty occurs in interpreting the results of the analysis in that the data set is incomplete, since the full range of debris is not reflected in the frequency tabulations from any of the proveniences at the site. That is, the smallest—material size-grade 4 and below—is not included in the regression. Should relatively low frequencies of material in these size-grades be present, as is hypothesized, the slopes would indeed be considerably flatter. Future investigations at this or other quarry sites should include the recovery of a full range of debris in order to adequately address this question.

In terms of the third item, an unstated assumption behind the observation may concern the effect of the lack of primary lithic sources on the Coastal Plain of Delmarva and the amount of sorting observed in secondary gravel deposits (Custer and Glasso 1980; Wittkofski 1982). That is, only scattered, secondary lithic sources are present and they are increasingly sorted with distance from glacial outwash areas at the fall line. Thus, both the size of tools and the debitage resulting from lithic reduction activities is expected to decrease with distance south on the peninsula, reflecting smaller raw material size and increased curation of tools manufactured from primary source material in the

Piedmont. As suggested by the regression statistics calculated for the Iron Hill East data, the incidence of small flakes may in fact be sufficiently uniform across the range of site types that such a connection would be difficult to distinguish. The pattern identified thus far is intriguing and may be real. The size of the sample, 12 sites, makes a definitive conclusion difficult to support, and invites further investigation.

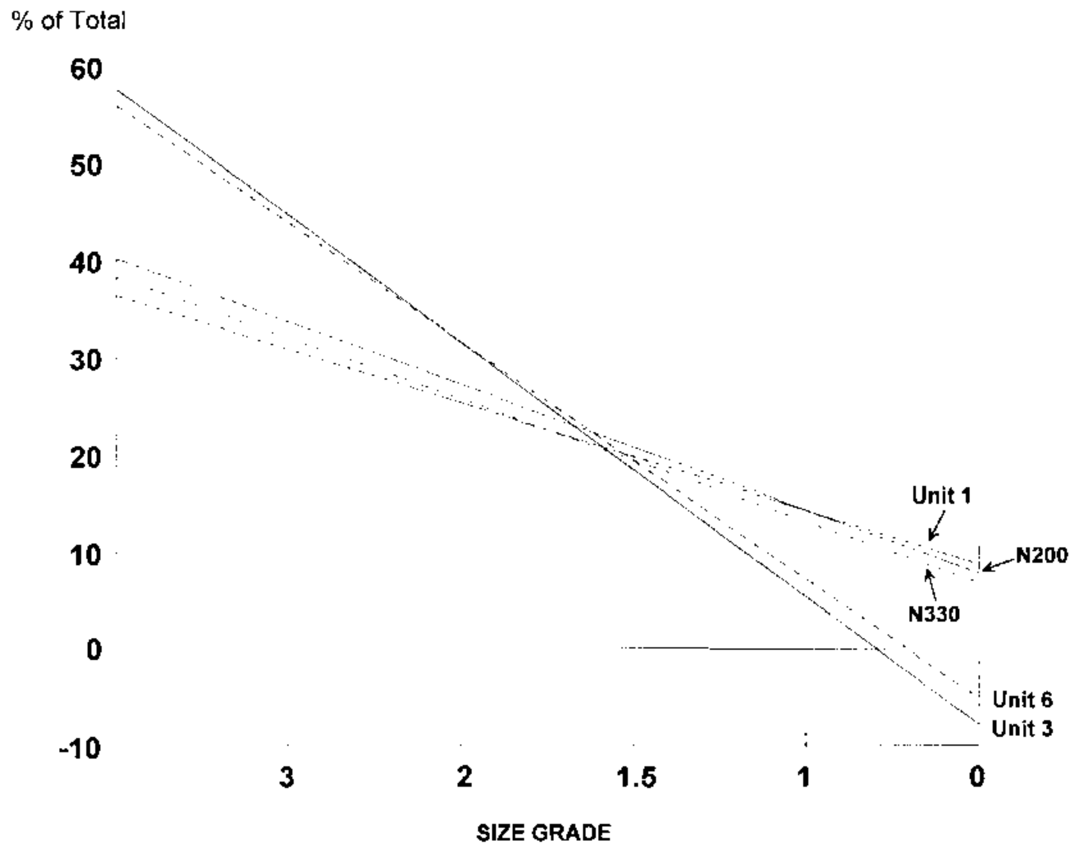


Figure 8-23. Iron Hill East: Linear Regression of Data from Selected Proveniences

Spatial Analysis

The horizontal distribution of prehistoric artifacts based on Phase II shovel test data was plotted on an isopleth map (Figure 8-24). A surface plot of the same data was also constructed (Figure 8-25). Isopleth maps tend to show the data in greater detail, and thus they have been used in the remainder of the analysis. The distribution plot showed a spread of lithic debris throughout most of the western portion of the study area, with the highest concentrations occurring on the terraces above the unnamed stream crossing the site between N320 and N340. In the western portion of the study area, shovel tests contained from 3 to 8 artifacts, while one isolated shovel test contained 32. Two other areas of concentration lay at opposite ends of the study area. At the southern end of the site grid, centered around N200 E210 and N210 E210, shovel tests yielded from 5 to 21 artifacts each. This portion of the site lay near a small ephemeral stream running south of the study area boundary. At the north end of the study area, overlooking a series of drainages running to the northeast, shovel tests contained from 1 to 5 artifacts. Close interval shovel testing was used to further investigate several positive shovel tests with relatively high artifact frequencies but little surrounding data (Figure 8-26).

The six test units excavated subsequent to systematic shovel testing were placed in areas chosen on the basis of relatively high debris counts within the systematic test grid. In most cases, artifact frequencies in these excavations were proportionate to those in the surrounding shovel tests (Figure 8-27). The major exception was Unit 4, which yielded considerably fewer artifacts than the nearby shovel test at N330 E240.

The distribution of reddened lithic debris was plotted and overlaid on the general artifact distribution as a potential indicator of specific areas related to the heat treatment of lithics at the site (Figure 8-28). The occurrence of reddened material was similar to the general distribution. Figure 8-29 shows the percentages of reddened material in unit proveniences and the two shovel test proveniences with high debris frequencies. In most cases in which sample sizes were reliable, reddened material comprised 25-30 percent of the debris from the provenience. The data appear to suggest that heat treatment of jasper was consistent across the site. An alternative possibility is suggested by the informal experimentation in heat treatment carried out in association with the investigation. The jasper and limonitic material from Iron Hill was found to change color readily—at comparatively low temperatures (cf. Purdy 1981:123) and in a short period of time. It

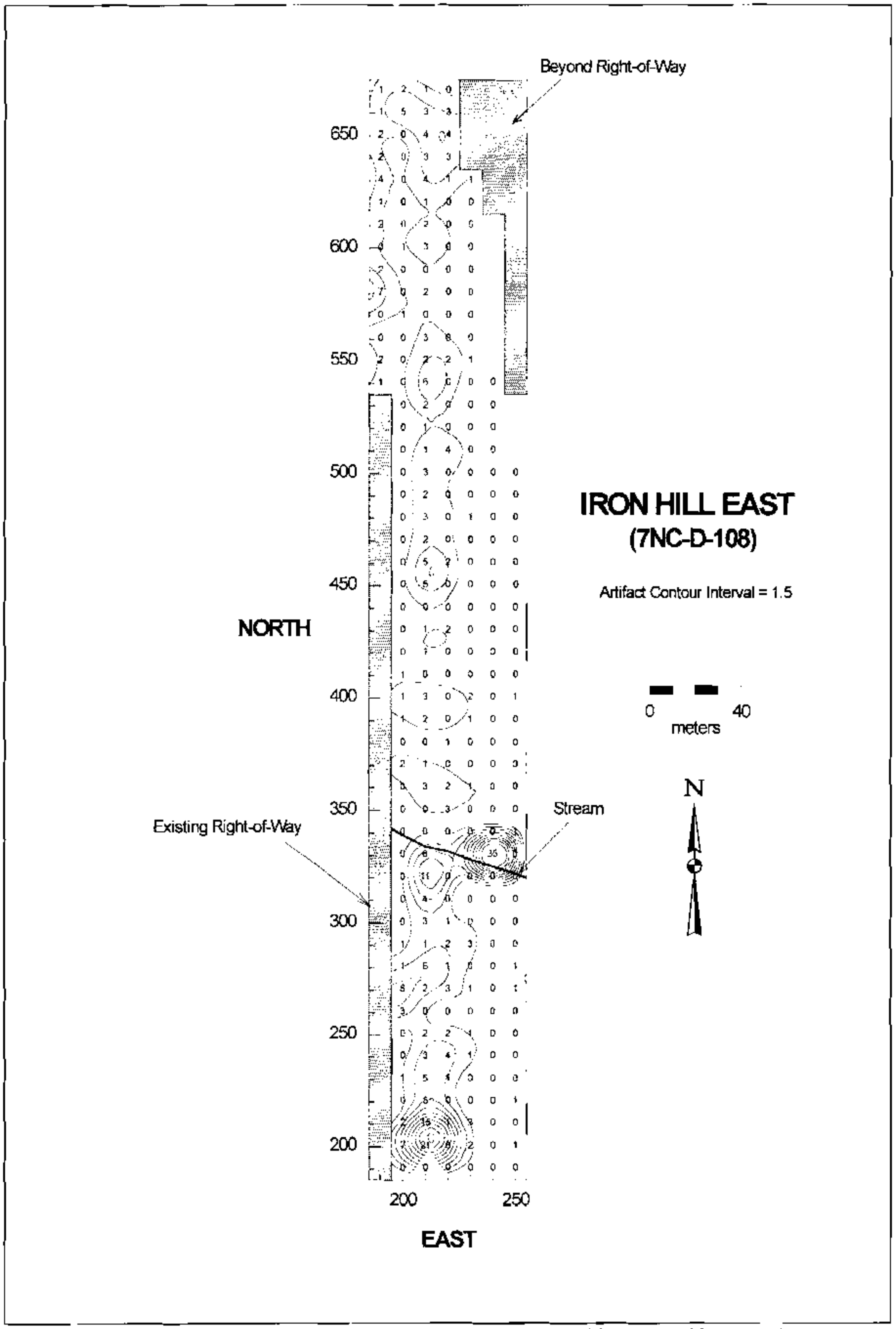


 Figure 8-24. Prehistoric Artifact Distribution

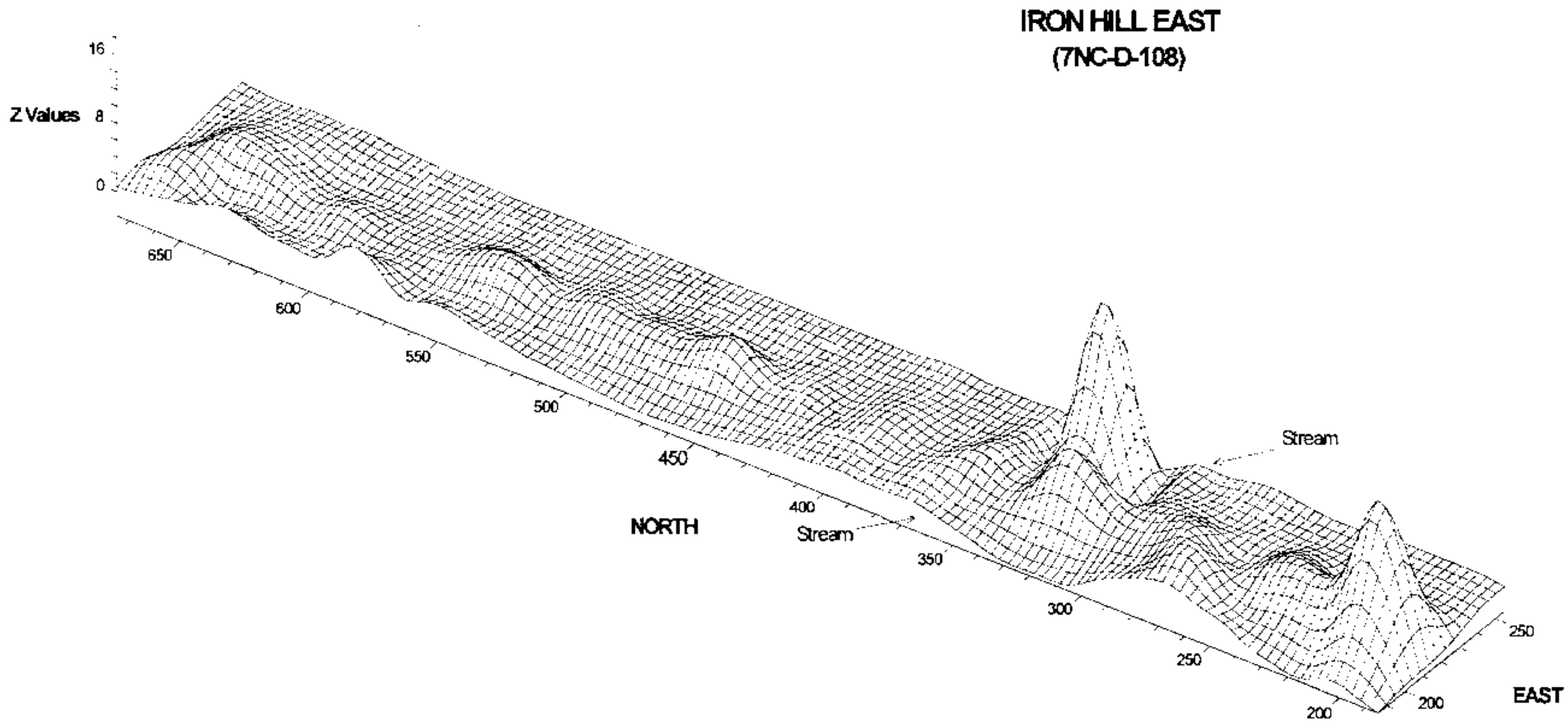


Figure 8-25. Surface Plot of Prehistoric Artifact Distribution

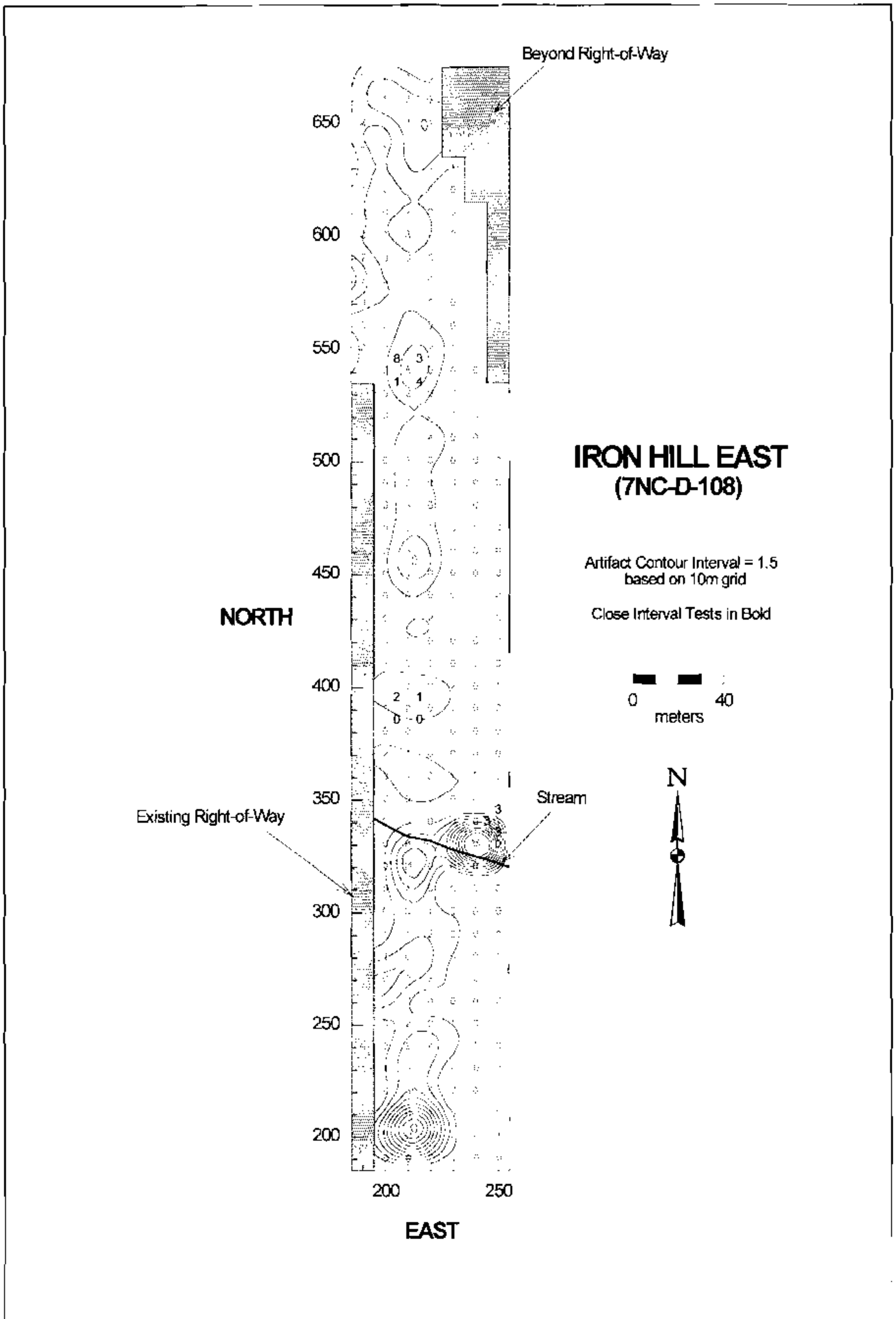


Figure 8-26. Close Interval Shovel Testing

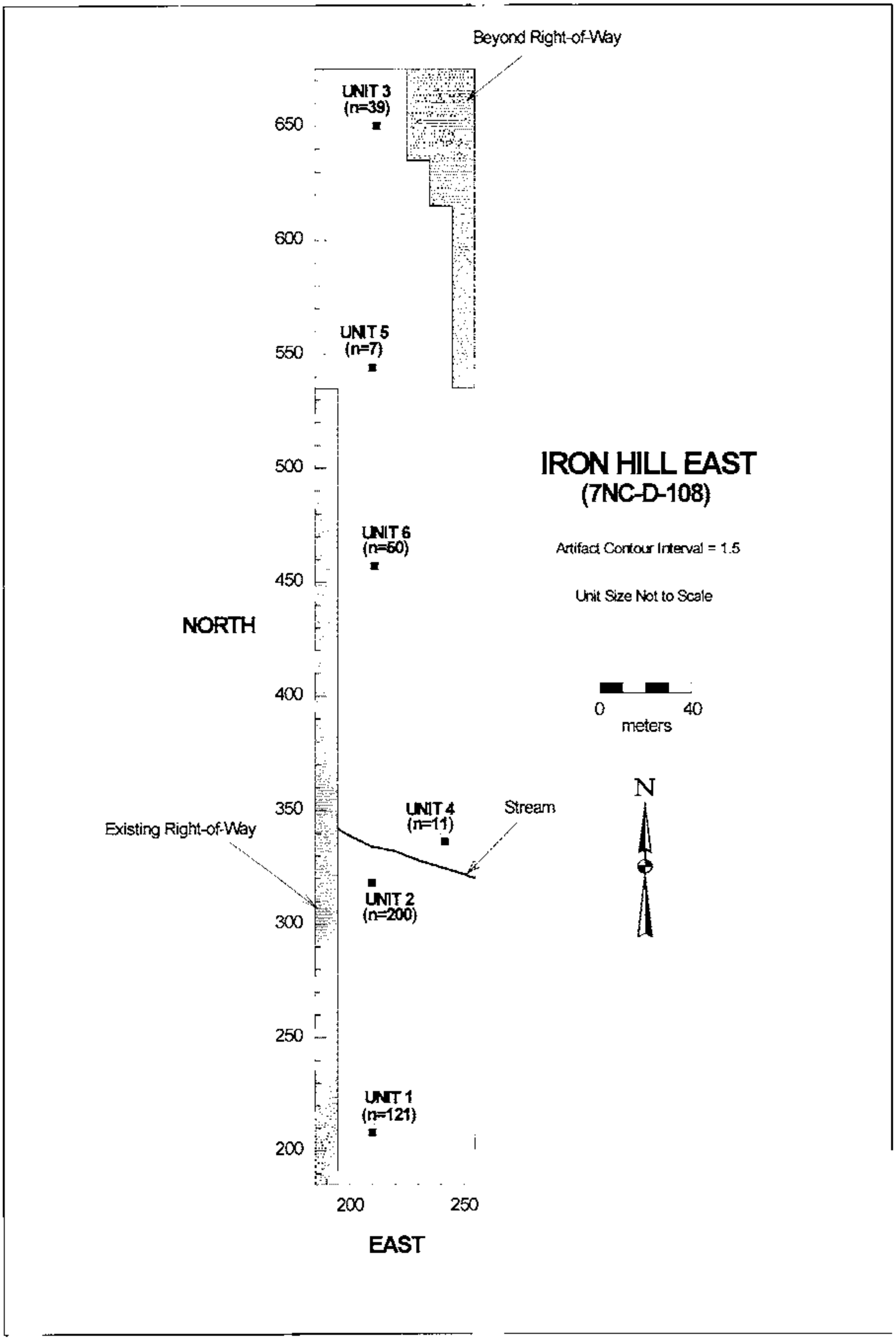


Figure 8-27. Test Unit Locations and Artifact Frequencies

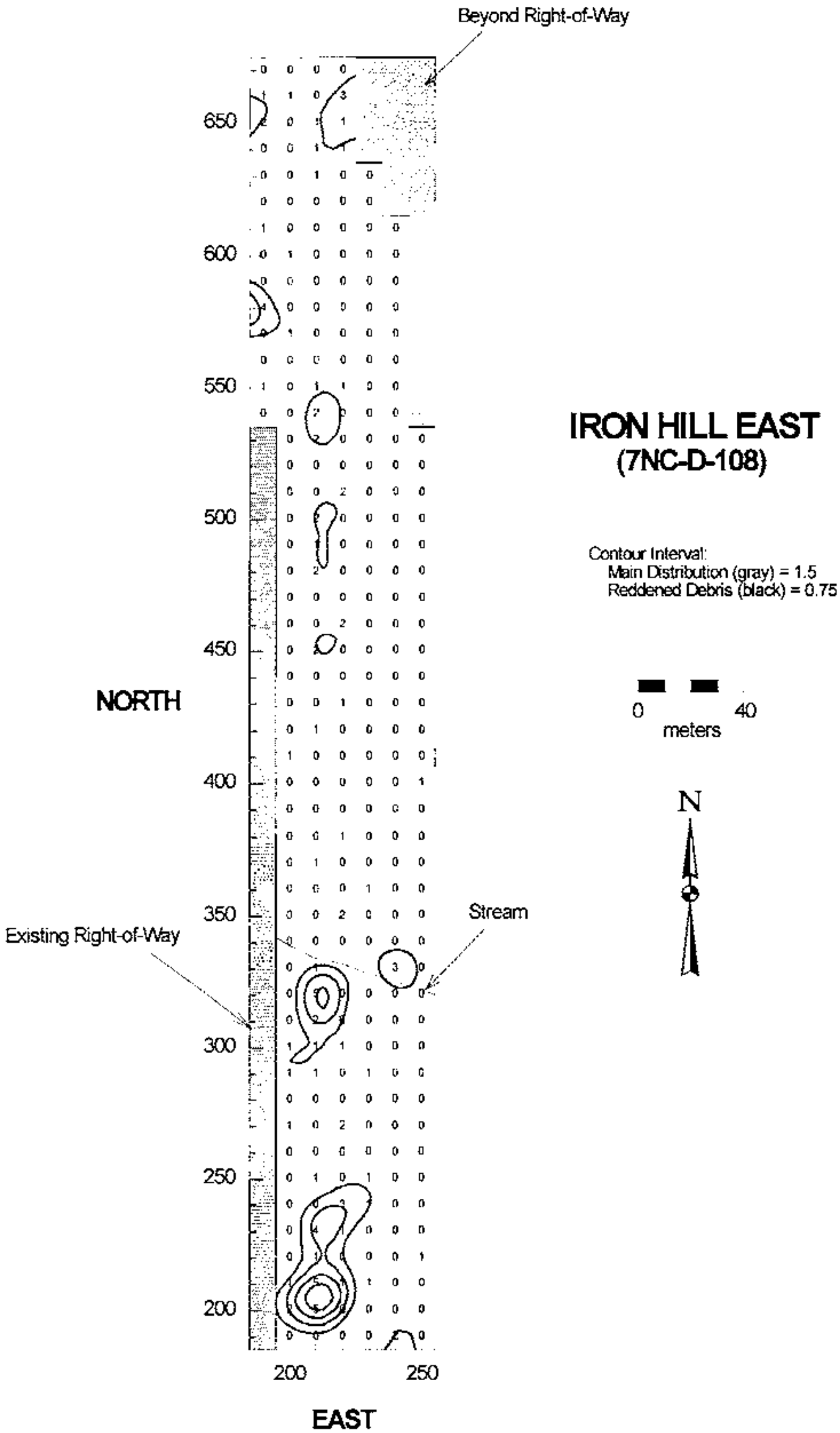


Figure 8-28. Distribution of Reddened Lithic Debris

may be that the uniform distribution of reddened debris across the site area is merely the result of the heating of the material in natural fires.

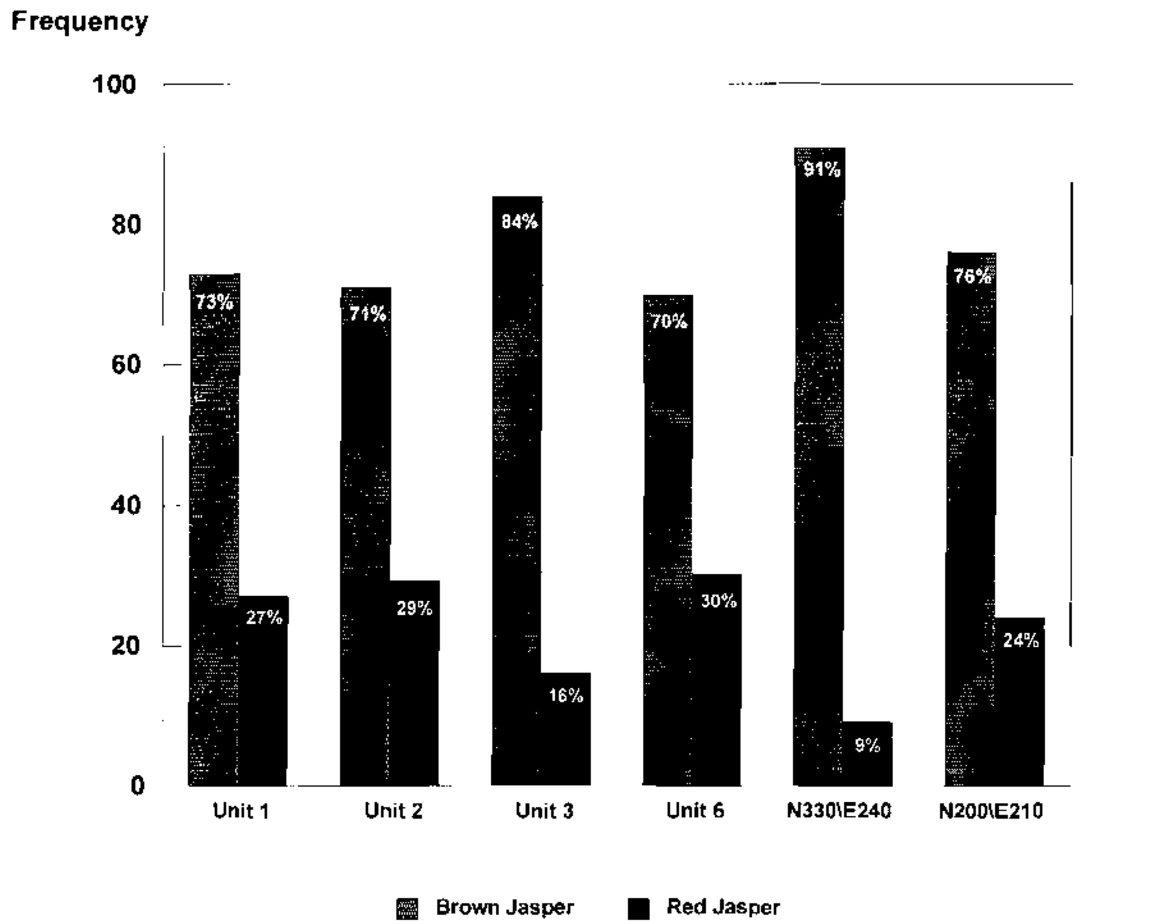


Figure 8-29. Relative Frequency of Reddened Lithic Debris

As a possible indication of areas in which biface reduction occurred, the distribution of flakes of good quality, cryptocrystalline jasper or other, non-jasper-related material was plotted (Figure 8-30). Artifacts included in the analysis were those exhibiting classic flake attributes or raw materials not directly associated with the Iron Hill outcrop-quartz, quartzite, chert, or rhyolite. Most of these flakes were small—90% were size-grade 2.5 or above—and most bore lipped, multifacted, or bifacial platforms. The assumption behind the analysis was the intuitive notion that small flakes of high quality jasper or of lithic material not available in the immediate area would represent the

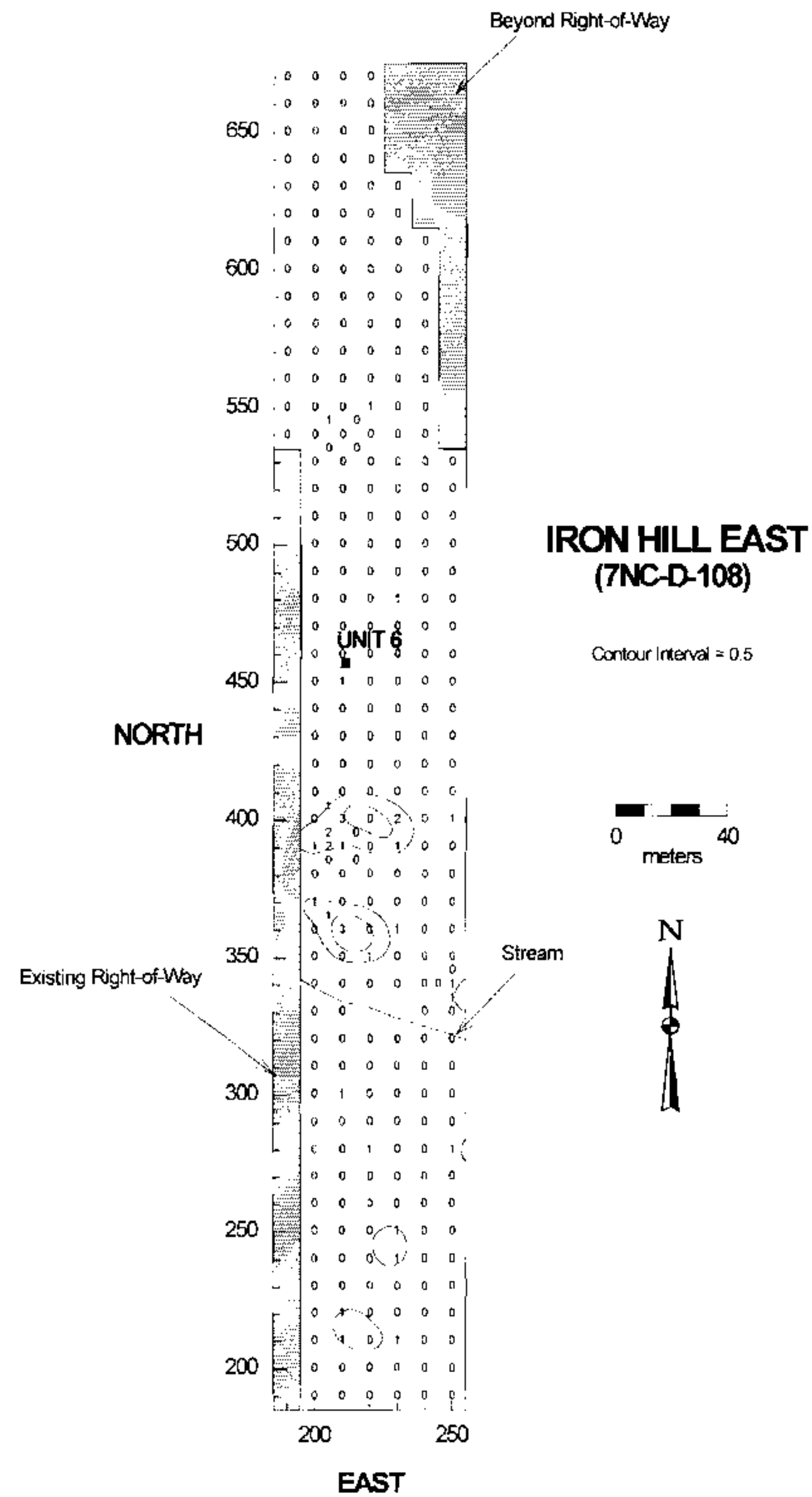


Figure 8-30. Distribution of Cryptocrystalline Flakes

remnants of lithic processing other than quarrying. No flake concentrations were recorded in the analysis. Notably, no clearly identifiable biface reduction debitage was recovered in the vicinity of Unit 6, the only provenience with flake size distributions suggesting biface reduction.

D. Interpretation

Artifactual material was recovered across a wide portion of the Iron Hill East study area. Historic period artifacts consisted of domestic and architectural remains with date ranges from the mid-nineteenth through the twentieth century. The horizontal distribution of the material appeared consistent with the arrangement of debris associated with road traffic and modern agricultural practices (Delaware State Historic Preservation Office 1993:45). No direct relationship could be drawn between the material and the historic period sites in the Cooch's Bridge Historic District. No further comparative analysis of the artifacts is thus considered appropriate.

A large volume of prehistoric lithic material was also retrieved from the site. In summary, the material was characteristic of the debris associated with a quarry site. The Iron Hill East site lay 600-800m downslope from known outcrops of cryptocrystalline quality material. Evidence from the artifact analyses conducted during the current investigation indicated that little if any of the debris resulted from biface reduction. Thus the material consisted almost solely a deposit of quarry debris, with little evidence of a quarry-related workshop, or other site type, present.

1. Comparative Analysis

Quarry Debris

As noted in the background for the Research Design (Section V of this report), comparative data related specifically to quarrying debris are rare in the archaeological literature. Most of the data are concerned with reduction debris from secondary workshop locales. Several UD/CAR studies have been conducted at quarry-reduction sites in northern Delaware, including 7NC-D-3, 7NC-D-5, and 7-NC-D-19, all located 2-3km north of Iron Hill (Custer et al. 1986a), and the Brennan site (7NC-F-61A), located 8km south of Iron Hill (Watson and Riley 1994). Data pertinent to quarry-related reduction observed at these sites is detailed in Table 8-10, along with similar statistics from Iron Hill East. The frequency of occurrence of cortical debris from the sites was generally noted as zero, as expected at workshop sites associated with a nearby quarry source. The recorded frequency of occurrence of cryptocrystalline lithic material ranges between 51 and 99 percent, implying the degree of specificity of site function; that is, the sites with the highest incidences of jasper were more likely to have been single purpose, lithic reduction sites of short-term use. Iron Hill East appears to compare favorably with its associated quarry-reduction sites based on these characteristics. Note that the difference of proportion test used by UD/CAR to account for sample size differences was not applied here. In addition, the extent to which direct comparability of the data can be supported is limited, since quarry debris was not present at any of the workshop sites.

Table 8-10. Lithic Resource Use at Selected Quarry-Reduction Sites in Northwestern Delaware[†]

Site	*Cortex*	*Cryptocrystalline Lithics*	*Reference*
7NC-D-3	0%	51%	Custer et al. 1986a
7NC-D-5	0%	60%	Custer et al. 1986a
7NC-D-19	0%	74%	Custer et al. 1986a
7NC-F-61A	1%	99%	Watson and Riley 1994
7NC-D-108	1%	96%	this volume

In terms of artifact diversity, Iron Hill East does not compare well with the same sites. Artifact types at Iron Hill East were almost entirely limited to flakes and quarry debris. As detailed in Table 8-11, other quarry-related sites in the area exhibited varying

[†] adapted from tables appearing in Catts et al. 1989 and Riley et al. 1994a

proportions of artifact types in comparison to flaking debris, but each site evidenced some artifact types other than debitage. Again, statistical tests were not applied to the comparative data from Iron Hill East. The almost complete lack of tool forms at the site made such tests unnecessary.

Table 8-11. Artifact Types at Selected Quarry-Reduction Sites Northwestern Delaware

Site	*Biface*	*Flake*	*Flake Tool*	*Point*	*Core*	*Total*
7NC-D-3	25	n/a	3	26	n/a	54
7NC-D-5	102	51	9	12	14	188
7NC-D-19	38	403	9	9	21	480
7NC-F-61A	6	1856	38†	0	3	1893
7NC-D-108	0	821‡	0	1	1	823*

†includes one artifact identified as a scraper
‡includes chips and flakes
*does not include hammerstone or fcr

Somewhat farther afield, investigations were conducted at the Pleasantdale quarry/workshop site, on the Hudson River in Rensselaer County, New York (Brumbach 1985). Comparison was made of debitage size based on mean flake weight between the Pleasantdale site and two other sites in the region, neither of which was identified as a quarry or quarry-related site (Brumbach 1985:106, Table 12). The purpose of the comparison was to demonstrate a fall-off in flake size in proportion to distance from the presumed quarry locale. The mean weight of quarry debris from Iron Hill East was calculated for comparison with the Pleasantdale site and was found to be substantially greater: Pleasantdale—3.48gm; Iron Hill East—17.91gm. It is not clear from the written description of the Pleasantdale analysis what data were included in the calculation of mean weight, but the figure appears to represent all debitage from the site, rather than quarry debris alone. The mean weight of the entire range of debitage from Iron Hill East—17.76gm—was little different from that of the material identified as quarry debris.

The implication of differential site function is clear, and supports the earlier analyses in the current study that indicated that the portion of the Iron Hill East site lying within the study area appears to contain little workshop debris.

Other quarry-related studies noted in Section V provide even less comparable data. In most cases, quarry debris, if noted at all, is dismissed as overwhelming in volume, with the implication that it is of little research value.

Constituent Analysis

As noted earlier, the jasper outcrops of the Hardyston formation, in the Middle Delaware Valley, represent a series of well-studied lithic deposits in terms of chemical composition. Trace element analysis was conducted of material from sources in Pennsylvania and Delaware by Blackman (1976), using atomic absorption and flame emission spectroscopy. Blackman observed that there was little chemical variability observable within the Newark jaspers, suggesting that the chemical signatures of the outcrops may be unique. Iron Hill jasper may thus be discriminated from jasper originating from quarries in Pennsylvania. The sample size was low (8 samples from two analyses), and there is some variability in the results of two preliminary studies (Blackman 1976; Stevenson et al. 1990). Nonetheless, the prospect is encouraging. Neutron activation analysis was conducted on jasper samples by researchers from The Pennsylvania State University (Hatch and Miller 1985). Discriminant analysis of data from 132 samples from seven quarry sources, including Flint Run in northwestern Virginia, Houserville in central Pennsylvania, four sources from the Hardyston formation, and Iron Hill, was successful in distinguishing among regional sources on the basis of eight elements, though less successful among sources within the Hardyston formation (Hatch and Miller 1985:230).

A later study (Stevenson et al. 1990) employed X-ray fluorescence to characterize the chemical composition of jasper from three Middle Atlantic quarries—Durham and Vera Cruz, in the Hardyston formation, and Iron Hill—using the X-ray spectra of 13 elements. Going beyond the results reported by Hatch and Miller (1985), the study was able to distinguish between all three sources (Stevenson et al. 1990:51-2). The results were applied to artifact samples from two sites in Chester County, Pennsylvania, the Kasowski site (36CH161) and the Woodward site (36CH374), both of which are located relatively close to the Newark jasper outcrops at Iron Hill. Analysis suggested that lithic raw material from those sites was derived from several sources, though mainly those in the Hardyston formation, located considerably farther away than the Iron Hill source.

Constituent analysis was not conducted on material from Iron Hill East in association with the current investigation, but the results of the documentary search on the subject suggested that such analysis could be fruitful in more definitively assessing the chemical signature of jasper from the outcrops.

Heat Treatment

Data from studies in various locales in Delaware and across North America suggest that fire may have been used in the quarrying of jasper from Iron Hill. To reiterate material presented earlier, fire was reportedly used in quarrying at Flint Ridge, in Licking County, Ohio (Holmes 1919). Purdy (1981) noted two eyewitness accounts of fire-related quarrying, one an ethnohistorical account from California, and the other an ethnographic observation from modern-day Australia (Binford and O'Connell 1984). The liberal use of fire in quarrying at Tosawihi, a chert quarry in north central Nevada, is also reported (Carambelas and Raven 1991). Experimental work at that site suggested that heating served to weld the surrounding tuff allowing it to be removed in large chunks. Heat also helped to initiate cracks in the underlying opalite that could be used to gain access, e.g., purchase for wedges. Purdy (1981) conducted her own experiments in heat treatment in association with chert encased in limestone, rather than the loose tuff surrounding the cherts at Tosawihi. Her conclusion was that heating was destructive, and could be used to "demolish...unwanted material," but could not be controlled sufficiently for use in removing tool-quality stone (Purdy 1981:76).

A study of the thermal alteration of Bald Eagle jasper, from central Pennsylvania (Schindler et al. 1982), deals extensively with the details of chemical modifications resulting from heating. Analysis of archaeological assemblages in the study focuses on the heat treatment of bifacial cores. That is, the study deals with the use of heat treatment as an aid to biface reduction, rather than as a quarrying technique. An interesting pattern in the incidence of thermally altered flakes is reported, though the implications are not followed out in detail. Heat treatment occurs at considerably lower frequencies for flakes identified as primary thinning flakes than for early or later stage thinning flakes (58 percent compared with 16 and 20 percent, respectively [Schindler et al. 1982: 539, Table 1]). The implication drawn by the researchers was that heat treatment was undertaken only after the initial edging of the biface. A further implication may be that there was little or no application of heat associated with the quarrying process at this locale.

At Iron Hill East, some reddened material present, indicating that the material had been heated. Red jasper also occurs at quarry-related sites in the area at which jasper, presumed to be from Iron Hill, was reduced: e.g., the Hitchens site (18CE37), an Archaic-Woodland I period lithic reduction and short-term occupation site associated with the Iron Hill Cut Quarry (18CE65) and located 4km northwest of Iron Hill; or the Bumpstead site (18CE162), a small, Woodland I period reduction site approximately 8km north of Iron Hill. In addition, all of the jasper recovered at the Brennan site (7NC-F-61A), approximately 8km south of Iron Hill, was red. The high frequency of red material at that site, including bifaces and flake debris, along with a perceived lack of other characteristics of heat treatment, such as pot-lidding, led the analysts to conclude that the coloration was natural, and not due to thermal alteration, either natural or cultural. This inference was made despite mineralogical data indicating that the Newark jaspers from Iron Hill are yellow to brown in color (Custer et al. 1986a; Vidal 1988). Vidal (1988:8) notes that while hematite is present in the jasper, red hematite does not occur "due to the lateritic processes" associated with deposition at Iron Hill. "The limonitic iron oxides dehydrate to hematite Fe_2O_3, if heated, turning the rock brick red in color [Leavens

1979:188]. The yellow limonite only alters to red hematite after secondary heating has occurred."

Assuming that reddened material was in fact the result of heating, the incidence of heated treatment at Iron Hill East was difficult to assess due to an absence of directly comparable data. In most proveniences at the site, reddened debris accounted for approximately 30 percent of the debris total. This is a relatively low frequency, in comparison with figures from workshop sites associated with the Hardyston formation quarries, where up to 60 percent of early stage biface reduction debitage exhibited signs of heat treatment (Schnidler et al. 1982). The evaluation of the comparison is not straightforward, though, since reduction activities varied between the sites.

Informal heat treatment experiments carried out as part of the current investigation indicated that the raw material from Iron Hill turned red in a relatively short time and at relatively low temperatures. Thus it is possible that the red lithic material recovered was mostly the result of heating in natural fires. The frequency of the heated material argued for cultural agency. Yet, the debris was distributed comparatively evenly across the site, with little differential distribution between reddened and non-reddened debris, again suggesting heating resulting from widespread, and thus natural, fires.

Context

The relative absence of knappable, cryptocrystalline jasper, or of hammerstones or obvious concentrations of debitage within the study area suggests that the debris recovered during the investigation was not necessarily in primary context. The location of outcrops nearby is not known. In terms of the lack of hammerstones, Singer and Ericson (1977:179) observed a low frequency of hammerstones at the Bodie Hills quarry in central California. They reasoned that "initial percussion for decortication or core preparation was accomplished using a direct block-on-block or cobble-to-cobble technique." No evidence of comparable use of raw material blocks as percussors was noted at Iron Hill East.

A similar contextual situation, with apparent quarry debris located some distance from cryptocrystalline outcrops, has been reported in association with chert quarries occurring in the Epler and Ontelaunee formations located in the Wallkill Valley of northern New Jersey (LaPorta 1990). Extensive debris piles have been observed which accumulated as quarriers extracted tool-quality stone from the surrounding dolomitic carbonates. The chert, still encased in masses of dolomite, was often transported considerable distances downslope from the outcrops for further processing (LaPorta, personal communication 1995).